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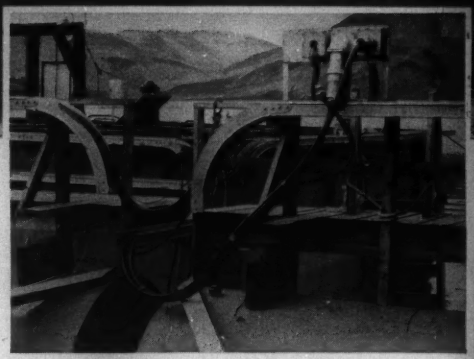
75th Anniversary
1884 – 1959
75 Years
A Prologue to the Future

Courtesy General Mills

THE COVER: Stratoscope I balloon flight which resulted in 400 of the "sharpest pictures ever taken of sun spots." Used was a 12-inch telescope—camera equipped with a closed-circuit TV camera and remote-control mechanism enabling the research team to guide it as well as see on the TV screen the area under observation. Story on p. 1058.

This is the "fish net"—stretching more than a half-mile across the reservoir behind Idaho Power Company's Brownlee Dam in the Hells Canyon reach of the Snake River, bordering Idaho and Oregon. The migrant fish facility, designed to save salmon and steelhead from a drop over the spillway of the 395-foot-high Brownlee Dam, depends on Okolite-Okoprene 600-volt power and control cable for continuous, all-weather operation. Fish trapped at three skimmer-barges attached to the net are taken by specially designed trucks for release down-river.



Here is Okolite-Okoprene on the job, providing power to two 21,000-gallon-per-minute pumps which create artificial currents that lure the fish into channels in the trap. Multi-conductor control cable also enables a complicated maze of control equipment—almost completely automated—to be operated both from the barges and a shore station.

Idaho Power chooses Okolite-Okoprene cables for power and control at "world's biggest fish net"

Okolite-Okoprene 600-volt power and control cable is at the heart of Idaho Power's new fish conservation facility behind Brownlee Dam in Hells Canyon, on the Idaho-Oregon border.

The "world's biggest fish net"—300,000 square feet in size behind the giant Snake River dam—depends on nine-conductor Okolite-Okoprene control cables to carry current to almost completely automated control equipment. And Okolite-Okoprene three-conductor power cables provide power to motors driving two 21,000-gallon-per-minute pumps which create artificial water currents, luring fish into channels in the trap.

Both Idaho Power and International Engineering Company, the consulting engineers, specified Okolite-Okoprene for the project, seeking maximum operating dependability. The cables are constantly exposed to weather and, in the center section, are submerged in water. Their flexible stranding helps them withstand the movement of the barges on the lake, as well as handling during removal of barge sections or traps.

At the "world's biggest fish net," as in other projects where maximum dependability and proved service life are required, Okolite-Okoprene was recognized as the best cable for the job. Its long life and dielectric strength . . . its resistance to corona cutting, moisture, heat, chemicals and mechanical damage make it the most reliable cable on the market. For the full story on Okolite-Okoprene, write for Bulletin EG-1085. The Okonite Company, Subsidiary of Kennecott Copper Corporation, Passaic, N. J.

where there's electrical power . . . there's **OKONITE CABLE**

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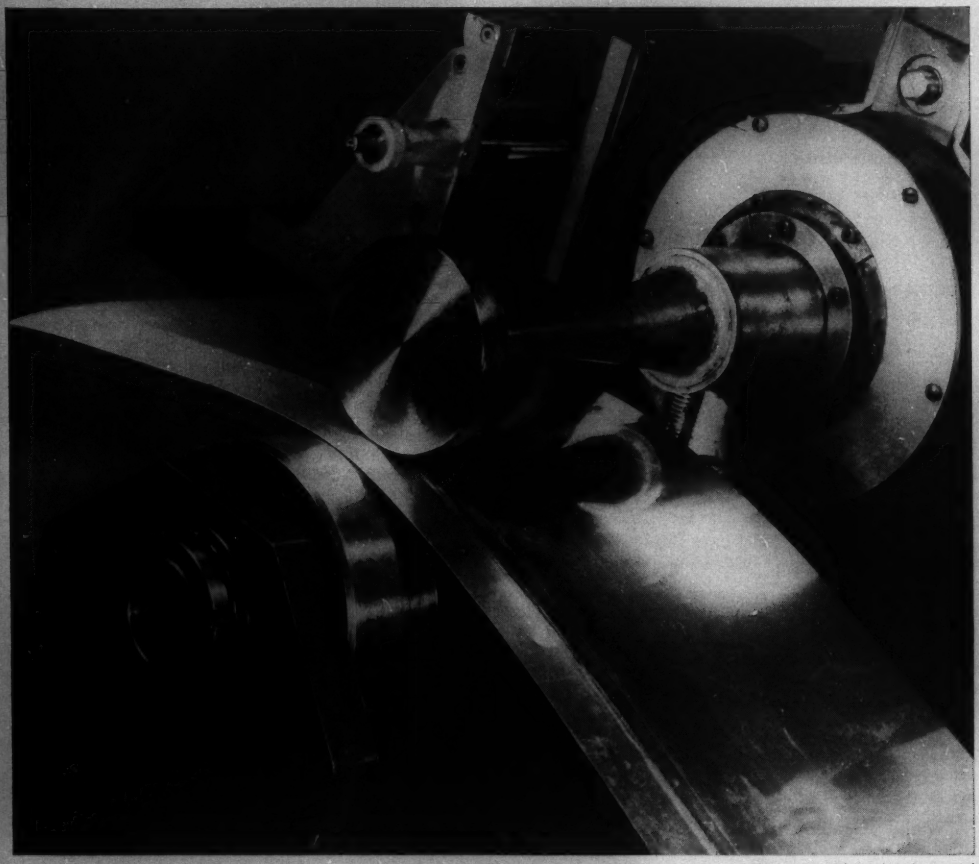

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A Salute to the American Institute of Electrical Engineers

Responsibility for applying discoveries of science to mankind's needs resides with the engineer. The field of electricity in the 19th Century and its 20th Century electronics offspring have presented to engineers one of history's greatest challenges and opportunities for service to mankind.

The history of contributions by electrical engineers proves the dedication and skill with which they have met the challenge. The bold innovations in electrical engineering and electronics seen everywhere in aviation prove the opportunities were grasped with enthusiasm and audacity.

Electrical engineers have had, and will continue to have on a growing scale, a pivotal responsibility in the application and utilization of aviation for mankind's benefit.

Whether for civil or military aviation, whether for the pursuits of defense or the normal peaceful pursuits of man, the efforts of electrical engineers will continue to be vital to aviation technology and its expanding role in human progress.

I congratulate the American Institute of Electrical Engineers on its 75th Anniversary and its members on their achievements and future prospects.

E. R. Quesada

Administrator
Federal Aviation Agency

75 Years—
A Prologue to the Future

The Outlook for Computer Control

I. M. STEIN
FELLOW AIEE

The future of computer control for the process industries looks bright, but its full potential will not be realized until the process itself is susceptible to such control. Computer control, it is stressed, is not a substitute for present conventional control but a refinement.

THE FUTURE of computer control looks bright; however, some words of caution are in order. One can have sound and conservative optimism without giving way to unsound and unbridled overenthusiasm.

Some producers of computers who have only recently attempted to enter the field of automatic control of continuous processes are, in my judgment, promising too much too soon. Among these newcomers to the automatic process control field are companies whose competence in the field of computer techniques is excellent, but there is much more to the automatic control of continuous processes than sound computer techniques.

I am much concerned about the setback computer control may experience if, as the result of promising too much too soon, there are many disappointments in actual performance. This situation has already developed in the application of computers to office procedures. Notwithstanding the tremendous success of computers in certain technical, statistical, and military applications, there have been too many unsuccessful office applications. In these cases, after the expenditure of much time and money in preparatory work and the purchase of expensive equipment, the promised savings, or other benefits, have not materialized. John Diebold, a recognized authority in this field, commented on this situation in *Dun's Review and Modern Industry*, August 1958, as follows:

> "But the revolution has not really got off the ground. Business men—even those who were willing to settle for less than a revolution if operations were improved or money saved—have been disappointed. In business after business, installations have not lived up to expectations. Savings have not materialized. Planned applications have been abandoned. Operations have not been speeded up. Inventories have not been reduced, and management reports have not been improved. All these goals—modest enough, certainly, when they are stacked up against a promised revolution—seem to remain maddeningly just out of reach."

It is pertinent to recall the setback experienced in the application of electronics, particularly vacuum tubes, after these devices first became generally available in shops catering to the users of radio receiving sets. Because of the amplifying feature of vacuum tubes, many users and some suppliers of measuring instruments and control devices rushed in to take advantage of what they mistakenly believed to be a new order of sensitivity in measuring and control circuits. The result was not good and, as a consequence, when vacuum tubes and their related circuits had been developed to a satisfactory degree of reliability, many purchasers who could have benefited by the use of electronic devices shied away from their use because of the bad reputation that premature claims and promises had given them. Actually, many years before electronic devices were generally available, galvanometers with optical or thermal amplification had been used down to the natural limit of sensitivity (as fixed by the Brownian motion in the suspended system), and with a response time of about 0.01 second. It was many years later before electronic devices could be used down to the equivalent natural limit of sensitivity (as fixed by the so-called Johnson noise). Of course, what made the electronic approach so attractive was the first impression that relatively high sensitivity could be achieved with compact and inexpensive apparatus, but stability and reliability were lacking. As the result of the contributions of many workers in this field, electronic detectors and amplifiers were eventually stabilized and otherwise made reliable. By the time the necessary features were added to provide this stability and reliability, the electronic devices were not so compact or inexpensive. Nevertheless, they had numerous other advantages, so that their use has not only become widespread but both their size and cost have been reduced remarkably.

THE DIRECT-CURRENT AMPLIFIER

STABILIZED D-C AMPLIFIERS, having appropriate characteristics, have come into extensive use in many types of computers. Accordingly, I think it would be helpful to sketch very briefly the major steps involved in achieving those characteristics. Specifically, to be satisfactory for use in a variety of computers, these d-c amplifiers must operate over a relatively wide frequency band, must have a highly stable zero together with

Essentially full text of the keynote address delivered at the 14th Annual Symposium on Instrumentation for the Process Industries, conducted by the Department of Chemical Engineering, Agricultural & Mechanical College of Texas, College Station, Texas, Jan. 21, 1958. Recommended for publication by the AIEE Feedback Control Systems Committee.

I. M. Stein is president, Leeds & Northrup Company, Philadelphia, Pa.

highly stabilized and linear "gain" or amplification.

As part of his pioneering work on the Electronic Potentiometer (U. S. Patent No. 2,113,164), A. J. Williams, Jr., devised several forms of amplifier for use with low-level d-c input and having an inherently stable zero. These amplifiers served their intended purpose very well, but were useful over a relatively narrow frequency band of only a few cycles per second. Also, in that application, only a limited stability of gain was necessary.

At about this time, H. S. Black was striving to develop an a-c amplifier useful over broad frequency bands and having a high degree of stability and linearity of gain. His work was brought to a very successful conclusion through his ingenious invention of "negative feedback."[1,2] Because Black was concerned only with a-c amplifiers, he did not need to be concerned about zero stability. When applied to d-c amplifiers, Black's negative feedback principle provided the same high degree of linearity and stability of gain, but did not provide a stable zero.

For a while, many leaders in the field of electronic amplifiers appeared to take the position that in d-c amplifiers, broad frequency band characteristics and a high degree of zero stability were mutually exclusive. In other words, they seemed to feel that in d-c amplifiers, one could have either a stable zero with only a narrow frequency band or that one could have broad frequency band characteristics without a stable zero, but that one could not have both broad frequency band characteristics and a stable zero in the same amplifier. However, Williams did not accept this view and proceeded to devise an auxiliary circuit for stabilizing the zero of broad-band d-c amplifiers. Apparently, some workers at the RCA Research Laboratories, and still others in England, had the same idea at about the same time. This led to interference proceedings in the U.S. Patent Office which recently have been settled so that suitable cross-licensing agreements could be concluded.

The result of all this is, of course, that highly stabilized amplifiers having characteristics suitable for use in computers are now available and are being extensively used, particularly in computers of the analog type. Many in the process industries will recognize these as the so-called "operational amplifiers." Such computers are being used for analysis, for automatic control, and for other purposes.

The significant point is that it has taken nearly four decades from the time that vacuum tubes first became generally available to develop electronic detectors and amplifiers having the stability, reliability, and flexibility needed in the field of refined measurement and automatic control. It has taken nearly three decades for the first d-c stable-zero electronic instrument to become available for this class of work; and there is still room for improvement. I think it can be assumed that progress will be more rapid in the future, with full fruition of digital computer controls taking a somewhat shorter time, but certainly not less than a year or two. This optimistic progress on the future of these computer controls can be marred however, by setbacks that could easily occur as the result of promising too much too soon.

DEVELOPMENTS IN REFINED AUTOMATIC CONTROL

Before proceeding to give my views about the future of computer control, a brief review is in order about a few of the most significant steps in the development of refined automatic controls. It is necessary to keep in mind some of these significant steps in order to see the role of computer controls in proper perspective.

I shall use some old-fashioned general terminology, instead of the more precise and specific terminology that has been adopted by the experts in recent years because the more general terminology seems more appropriate for my present purpose.

It is well known that the earliest automatic regulating controls that came into general use were speed governors, used first on steam engines and then on steam turbines. Later, there were the simpler forms of damper controls for furnaces. To avoid oscillation or "hunting," all of these controls were stabilized by giving them what we used to call "drooping characteristics." That is to say, in the case of speed control, as the load was increased on the engine or turbine, the governor maintained a progressively reduced speed. To reduce this change of speed with load, there were developed the so-called "isochronous" governors. The word means constant time, and the name indicates that they held constant speed—which they did *not* do. With ample power available to drive them, and through excellent design, these isochronous governors were much more sensitive than their predecessors, and, therefore, in going from light load to full load the range of speed was much reduced. But the drooping characteristic was still there to give stability. They served very well in their day, but would be quite inadequate for modern, large-scale electric power systems, in which the required constancy of frequency is controlled by very sensitive electrical devices responsive to the generated frequency.

It was not until World War I days that controls were devised which, while retaining the stability of the earlier controls, as provided by the drooping characteristic, effectively eliminated the drooping characteristic and, thus, brought about automatic control at a fixed value, regardless of load changes or other variables.

The manner in which this development occurred may be of interest. Along about 1910, M. E. Leeds had succeeded in devising robust, machine-like, recording instruments for temperature measurements in industrial plants. These recorders were of the "null" or balance type, utilizing potentiometer and Wheatstone bridge circuits. Incidentally, I believe that this was the beginning of "moving the laboratory out into the plant," which expression we frequently hear today in connection with the introduction of a new process instrument. The use of these sensitive, wide-chart

recorders in industrial processes brought to light process phenomena neglected up to that time and now frequently referred to as process lags. Leeds analyzed these effects critically and was very quick to realize that they presented important limitations to refined control of industrial processes. His pioneer contribution to automatic control quickly followed. This contribution is described in an address[3] I presented to The Newcomen Society at the Franklin Institute, Philadelphia, Pa., about a year ago. I quote a paragraph from that address:

> "Following the introduction to industry of the first Leeds Potentiometer Recorder in 1912, it very quickly became apparent that these machine-like industrial measuring instruments could be equipped with certain auxiliary devices to provide automatic control of industrial processes. To suggestions from within and without his own organization that these instruments be equipped with simple "on-and-off" electrical contacts to provide automatic control, Leeds was very cool. He already had given considerable thought to automatic control because his industrial recording instruments involved in themselves some rather refined automatic control problems. He was satisfied that simple "on-and-off" control could not be expected to give good results in more than a few rather elementary applications. For the more difficult industrial control applications, he visualized the mental processes and the alert manipulations of an intelligent operator watching an array of measuring instruments and trying to make the adjustments necessary to maintain the desired conditions. He was convinced that unless an automatic control device took into account all of the factors, the weightings, and the timings that a good operator did, it would not be successful; but he also was convinced that an automatic control device that did take into account all of these things could do a better job than the best operator could do. His visualization of sound automatic control was reduced to mathematical formulas and to experimental apparatus design at the time he applied for his pioneer automatic control patent (U. S. Patent No. 1,332,182) in 1917. These principles form the basis of all refined automatic control today. In the more than 40 years since Leeds applied for his patent, further improvements have been made in automatic controls, but it is interesting to note that these improvements have come from adding factors and functions rather than by omitting any that Leeds considered essential."

The initial action in the Leeds control followed the earlier practice of providing stability by the use of the "drooping characteristic," but the initial action created almost simultaneously in the control circuit an auxiliary electromotive force which was "fed back" into the control circuit to return the temperature to a fixed value regardless of load and other conditions. This auxiliary electromotive force was applied in such a way as to return the temperature to a fixed or normal value just as quickly as the ever present process lags would permit. This was accomplished by making the "feedback" responsive not only to the magnitude of the departure from normal but also to the rate-of-return to normal. Thus, in controlling temperature, and assuming the temperature to be below normal for some reason, heat would be applied to prevent further reduction in temperature but, in addition to this action, the control would start to add more heat so as to bring the temperature fully back to normal at the maximum rate that could be tolerated without causing overshooting or oscillation. Here again, it should be emphasized that this maximum rate was fixed primarily by the process lags. The term "feedback control" is frequently heard today and the experts define several forms of feedback, but the basic use of feedback control had its origin in this contribution by Leeds many years before the term "feedback" was coined.

PROCESS LIMITATIONS INHIBIT CONTROL

In early applications of comprehensive and coordinated systems of automatic control to large boiler furnaces, and in other similar control applications, the refinements in the controls could not be made fully effective because of the lags and other limitations in the process itself. This should not be at all surprising, because in most cases the process layout and the process equipment were designed with practically no attention to the requirements of refined automatic control. Today, in designing a new process plant, the control requirements are considered from the very outset and this, of course, is essential if optimum control is to be achieved.

This is the first of two points that I wish to emphasize in reviewing the advances in refined automatic controls, namely, that the full advantage of advanced forms of control cannot be realized unless the process plant itself is susceptible to such control. This point will be referred to again in discussing computer control.

The feedback controls to which I have referred were for many years provided in most instances as an adjunct to a recorder. Even though the chart might be omitted, so that the instrument was only an indicator, the control operated through what was essentially a recorder mechanism. This arrangement introduced into the control function certain errors and certain time-lag in the recorder mechanism. The very-high-speed and sensitive electronic recorders devised by Williams, greatly reduced the instrument lag and error; but, when first placed on the market, these electronic recorders were rather large and expensive and these factors placed a limit on their use where large numbers of controls were involved. Since that time, both the size and cost of these instruments have been very much reduced. In the meantime, as the advantages of refined automatic control became more fully recognized and as the process plants were improved to be more susceptible to refined control, the error and time-lag in the recorder mechanism became limiting factors which it was de-

sirable to eliminate. This led to the development of direct or "blind" controllers which performed their control function directly—that is, without going through a recorder mechanism. Williams described[3] high-speed electronic feedback controls of this type for positioning valves and similar regulating devices and also for speed control of electric motors. The recorder when added to such systems became the adjunct to provide valuable assistance in attuning the control to the process and in spotting and analyzing quickly any disturbances that might occur either in the control system or in the process itself.

Such control systems are still undergoing development and improvement to make them better for today's needs and to adapt them to the needs of the future. In this connection, about 2 or 3 years ago, some technologists active in the field of process controls expressed the view that it was not worthwhile to improve such direct control systems further, because they would soon be made obsolete by the use of direct control from computers. I was not one of those who took this view seriously. It seemed inconceivable to me that in large-scale continuous processes a single complex unit would be entrusted with the basic control, so that if anything went wrong with the one complex unit all control would be lost. I am glad to be able to say that the large majority of our staff of technologists specializing in process controls was in agreement with my own views. A little later, a conference was held with a representative group of control technologists from Great Britain. The British have been very progressive in the field of automatic control theory even though, at times, they have allowed other countries to be the first to apply these theories. It was very comforting to learn that these distinguished British technologists were unanimous in their views that direct or "blind" controller systems would not be made obsolete by direct control from computers. This same position is supported by the consideration that much of the first cost and the maintenance cost of such control systems would be necessary anyway, even though the attempt were made to substitute computer control. From a number of recent articles in the technical press, one gets the impression that the idea of replacing direct or "blind" control by computer control has largely disappeared.

This is the second of the two points that I want to emphasize in reviewing automatic control advances. In other words, individual process-variable controllers are here to stay, and computer controls will be in the nature of an additive refinement, so that if the computer should fail to function properly, only the additional refinement which it contributes would be lost and the conventional control system would continue to provide stable operation just as it did before adding the computer refinement.

THE FUTURE OF COMPUTER CONTROL

THE FOREGOING BRIEF REVIEW of advances in the art of refined automatic control should have made it clear that computer control offers not a substitute for present conventional control, but a refinement achieved by addition to such control; and that the full realization of this additional refinement will depend upon the extent to which the process itself is susceptible to this additional refinement.

As an intermediate step toward computer control, a satisfactory computer can be of great value in analyzing the static and dynamic characteristics of the process to determine where the process operation may be improved from a control point of view and to appraise the prospects of the advantages to be gained by adding computer control. A logging system provides a periodic read-out, in digital form, of all the process variables and provides an auxiliary read-out, also in digital form, of abnormal performance at any of the control points or of any other process variables. This latter feature permits the plant operator to adjust the individual control points to give the optimum performance attainable in the process as it exists. Additionally, the computer may be used to calculate involved relationships and to print out "operating guide" information.

As is generally known, both the intermediate and the ultimate use of computers to improve the control of continuous industrial processes require what is called the "programming" of the computer. This requires determining the static and dynamic characteristics of the process and then adjusting the programming element of the computer to take these characteristics into account.

It should be obvious that for the programming adjustments to be correct for a reasonable length of time, the characteristics of the process itself must be stable over that interval, regardless of such factors as changing ambient temperatures and cleanliness of the system. It is possible by using what some control technologists have called "adaptive control" to have the computer automatically readjust its own programming to take into account changes in one, or a few, of the process characteristics; but if many of the characteristics required such treatment, the use of adaptive control could readily become impracticable for one reason or another.

It goes almost without saying that the successful application of full computer control requires a very high degree of reliability in the computer. It was because there were no computers available that appeared to be entirely satisfactory for this purpose that Leeds & Northrup Company, about a year ago, entered into a co-operative agreement with Philco to develop a computer of adequate reliability and having other suitable charactertistics. An unusual degree of reliability had already been demonstrated by the basic Philco computer in important military applications. The purpose of the co-operative development is to adapt the basic arrangement to automatic control of continuus processes without diminution of the basic reliability. Steady progress is being made and the outlook for achieving the desired result is quite encouraging.

Regarding continuous industrial processes themselves, the technologists of the operating companies

have been making extensive studies of process dynamics, but much remains to be done in this field before the prospects for full computer control can be properly appraised. I have already referred to advanced British work in the field of control theory. They are also engaged in advanced studies of process dynamics. Recently, I was informed that in England it is a definite requirement that most candidates for a degree in chemical engineering must have completed an adequate course in process dynamics.

"SEE-SAW" PATTERN FORESEEN

IT IS INTERESTING TO SPECULATE as to what will place the ultimate limit on computer control of continuous industrial processes. Will it be the limitations of computer controls, or will it be the limitations of the process itself? Some of the leading technologists in the process industries feel that the limiting factor will be the computer controls rather than the process characteristics. As an optimist engaged in the development and production of computer controls, I feel that the ultimate limit will not be in the controls. Based on past experience in the development of refined controls, which has been very briefly reviewed here, I expect a "see-saw" pattern in which both the controls and the process plant are continually improved with the limitation shifting from time to time from one to the other. At any one time, of course, the capability of the controls might be in advance of the capability of a particular process or plant to respond to the full capability of the controls, while in another particular process or plant, the reverse might be true. Probably the ultimate limit will be an economic one, wherein refinements in both the controls and the processes will have reached the point of diminishing return so that further refinements in either would not be economically justifiable. In any event, I feel we are a long way from ultimate accomplishment in either category.

In parallel with its developments in the relatively new field of computer control of continuous processes, Leeds & Northrup Company is carrying on several major developments which constitute improvements and extensions of process control systems, which it has been producing for many years. Computer control has already entered these developments in a major way, but the full extent to which it will be found justifiable is not yet clear. Neither is it clear whether the computers to be used in the ultimate developments will be of the digital or analog type. Probably there will be need for both.

For installations where they are applicable, analog computers, presently at least, are likely to be simpler, more reliable, and less expensive than digital computers. Also, analog computers are very useful and are rather widely used in "ratio" and "cascade" control systems.

Electronic analog computers, utilizing d-c signals for both the input and output circuits, provide great flexibility and permit combining the computer signals for various computing operations. This same flexibility makes these computers especially adaptable for use in end product control from suitable analyzing instrumentation. This is an active and growing field.

As an outstanding example of control through the use of combined or co-ordinated control systems, I may cite the comprehensive and complex continuous processes involved in the electric utility industry. Here the automatic control problems fall into three general categories: the heat generation, the electric energy generation, and the transmission of the electric energy to the points of ultimate use. Although the control systems for each of these categories have been developed as more or less separate entities, they are already being tied together to some extent into one comprehensive system and in the ultimate development all three categories are expected to be fully co-ordinated. Needless to say, this must be done to the fullest extent possible in ways that will isolate any failure to its own area and will not cause disturbances in other areas of control. Figuratively speaking, this involves a comprehensive system of automatic control "from the coal pile to the lamp socket on the customer's premises." This is figurative language because many utility companies use oil or gas, instead of coal, or some combination of them, and in the not too distant future new plants will be tending increasingly to heat generation from nuclear fuels rather than from fossil fuels. The controls for nuclear fuel plants are necessarily of a much different character from those for fossil fuel plants. For many years to come, however, most of the new capacity installed will involve the use of fossil fuels and many of these now in process and to be built in the future will utilize boilers of the "once through" type, an increasing number of which will operate at critical or supercritical pressures. The development of adequate controls for such high pressure boiler plants is fully as fascinating and challenging as the development of controls for nuclear power plants.

One reason for relating something of our development programs pertaining to large, comprehensive, continuous systems is that I believe the general approach I have outlined is a sound one to follow in striving for real success in the development of full computer control of large, complex, and continuous industrial processes. In other words, where possible—and it may not always be possible—it is better to segregate the whole complex process into several discrete major parts and to do a very thorough job of controlling each of these parts, instead of attempting as the first step to control the whole comprehensive system. When really satisfactory control of each such discrete major part has been achieved, it should not be difficult to co-ordinate the several parts to provide sound over-all control, particularly if this ultimate goal is kept in mind from the outset. I believe that this procedure will not only shorten the time to achieve ultimate success but will produce more reliable over-all control of a comprehensive system.

Computer control is already in use in the generation and transmission categories of electric utility system

operation. A computer of the analog type was installed on the Southern Company's network, approximately 5 years ago, and this was designed to accommodate full computer control at a later date. Full computer control of this network, which supplies many of the neighboring states, is in the process of installation. This control was installed to determine the generation at various sources for optimum transmission efficiency and was estimated to save the full cost of the installation in one year. It turned out that the actual savings, from loading units in accordance with computer directions, exceeded the estimated savings by about 100 %. Additional savings are expected when full automatic operation is completed.

Another analog computer control, known as a "Desired Generation Computer" was installed on the Southern California Edison system in September 1958. In this arrangement, the programming is done by the operator setting a number of dials to "instruct" the computer and from then on the control is fully automatic. Computer controls of this type are presently being built for several other interconnected power systems.

In the field of digital computers applied to industrial process control, about 1½ years ago Leeds & Northrup Company made its initial installation at the Esso Refinery in Baton Rouge, La. After preliminary adjustments had been completed, this unit went into 24-hour line operation on July 1, 1958. Although adaptable to full automatic control, this computer is used as a guide to the operators and for system studies which are essential prior to attempting full control. The 24-hour line operation continued for 24 days before a computer component failed. There have been additional failures of this same type. These failures were promptly corrected by replacing the defective components and were not serious in the present service of the computer. As indicated earlier, however, for full computer control more reliable computers are needed.

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An Elementary Design Discussion of Thermoelectric Generation

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This article seeks to acquaint the reader with the elementary problems of thermoelectric generation and some of the solutions that have been devised. Consideration is also given to advantages and disadvantages of thermoelectric generation for uses which may appear desirable at the present state of the art.

AT THE PRESENT TIME, many electric power sources of unconventional nature are being pursued vigorously in research and development. One of these, thermoelectric generation, has enjoyed renewed interest because of the development of semiconductor thermoelectric materials yielding efficiencies which are practical now for some devices and encouraging for others.

Semiconductor thermoelectric materials of practical use today have multiplied thermoelectric heat conversion efficiencies by a factor of 10, approximately, compared to metal thermocouples. This remarkable increase has brought thermoelectric conversion to a point of potential competition with electromechanical or other conversion for some applications. However, large-scale economic competition remains dependent upon significantly higher materials efficiency attainment. At today's state of the art, the uses to which thermoelectric generating devices are suited are those which value some feature more highly than maximum economy or which utilize very low-cost heat.

A COMPOSITE VIEW OF THERMOELECTRIC GENERATION

FIG. 1 presents a simplified view of thermoelectric generation as a complete, useful system. The usual ele-

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The author wishes to express his appreciation to E. J. Levin, W. G. Krawczak, and R. A. Elm for their contributions to the state of the art in thermoelectric generation. He also gratefully acknowledges the orientation provided by Dr. R. W. Fritts in successful use of the products of his semimetals research.

ments of a useful heat energy conversion system are apparent:

1. Heat input
2. Conversion apparatus
3. Heat rejection
4. Output control

These same four elements of a useful system may be readily compared to the (1) burner, (2) boiler-turbine-generator, (3) condenser, and (4) control system of a conventional steam generating system. Similar problems and similar general solutions apply equally to both, although the elements are physically different.

The major difference between conventional electromechanical generation and thermoelectric generation is that the boiler-turbine-generator conversion devices are replaced by one unit, the thermopile.

The thermopile, being a static device, inherently avoids many mechanical problems. However, substantial new problems appear as the struggle for realization of the semiconductor materials efficiency in practical generators is carried out.

THERMOCOUPLE FUNDAMENTALS

According to the relationships established and expanded upon by Fritts, Ioffe, and others, the Seebeck emf (electromotive force) E_{sc} or open-circuit voltage of a thermocouple is equal to the sum of the two thermocouple element voltages obtained by integrating the Seebeck coefficient S with respect to temperature between hot-junction temperature T_h and cold-junction temperature T_c.[1,2]

$$E_{sc} = \int_{T_c}^{T_h} S_p dT - \int_{T_c}^{T_h} S_n dT \tag{1}$$

The Seebeck coefficients of semiconductor materials are, in general, quite temperature-dependent. For accuracy in calculation of E_{sc}, the integrals as given in equation 1 must be used, but for simplification of the expressions to follow, average values of Seebeck coefficient multiplied by $(T_h - T_c)$ will be used rather than the integrals.

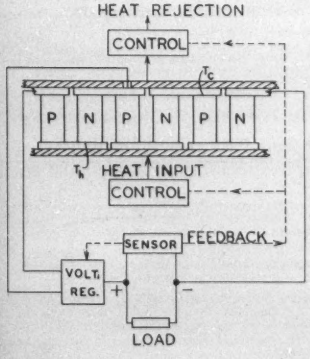

Fig. 1. Composite view of thermoelectric generation.

Connecting a thermopile of open-circuit voltage V_g, and resistance R_g, into a circuit of resistance R_L, the current in the circuit and power output may be defined by

$$I = \frac{V_g}{(R_g + R_L)} \tag{2}$$

$$P_0 = \frac{V_g^2 R_L}{(R_g + R_L)^2} \tag{3}$$

The internal resistance, R_g, of a thermopile is the sum of the element resistances. Like the Seebeck coefficient, the resistivity of semiconductor materials is temperature-dependent. The calculation of thermopile resistance, therefore, should be made by the integral

$$R_g = N\left[\frac{1}{A_p}\int_{T_c}^{T_h} \rho_p \frac{dx}{dT}\,dT + \frac{1}{A_n}\int_{T_c}^{T_h} \rho_n \frac{dx}{dT}\,dT\right] \tag{4}$$

where

N = number of couples

A = element area

ρ = electrical resistivity

Equation 4 can be evaluated when the variation of resistivity with temperature and temperature distribution within the thermocouple material are known. The following expression defines the relation of R_g to R_L at the condition of maximum efficiency:

$$R_g = \frac{R_L}{\sqrt{1 + Z\dfrac{(T_h + T_c)}{2}}} \tag{5}$$

$$\text{where } Z, \text{ figure of merit} = \frac{(S_p - S_n)^2}{(\sqrt{k_n \rho_n} + \sqrt{k_p \rho_p})^2} \tag{6}$$

Where Z is available plotted as a function of temperature for both p and n materials, the average Z value over the temperature range encountered may be used in equation 5. Z_{avg} is determined by:

$$Z_{av} = \frac{\displaystyle\int_{T_c}^{T_h} Z_p\,dT + \int_{T_c}^{T_h} Z_n\,dT}{2\,(T_h - T_c)} \tag{7}$$

It may also be shown for maximum efficiency that the cross-sectional areas of the thermocouple elements are related as follows when $L_n = L_p$, a condition which is usually desirable in thermopile design.

$$\frac{A_n}{A_p} = \sqrt{\frac{k_p \rho_n}{k_n \rho_p}} \tag{8}$$

With A_n/A_p established and thermocouple resistance $R_c = R_g/N$ known for any proposed thermopile design, approximation of the length-to-area ratios for the p and n thermocouple legs may be made through the relations

$$\frac{L_n}{A_n} = \frac{R_g/N}{\rho_n + \dfrac{(\rho_p \cdot A_n)}{A_p}} \quad (\text{when } L_n = L_p) \tag{9}$$

$$\frac{L_p}{A_p} = \frac{R_g/N}{\rho_p + \frac{(\rho_n \cdot A_p)}{A_n}} \quad \text{(when } L_n = L_p\text{)} \tag{10}$$

The physical size and weight of the thermocouple elements can be varied without affecting thermopile electrical design characteristics, so long as the ratios of L/A are observed. The final choice of exact L and A dimensions may be made on the basis of mechanical feasibility and available heat flux.

Thermocouple operating efficiency is expressed as the ratio of useful power delivered, I^2R_L, to the rate of heat input to the thermocouple. Rate of heat input is made up of loss rate by thermal conduction from hot junction to cold junction, input rate to drive the thermocouple cycle at the Carnot efficiency established by T_h and T_c, and half the I^2R loss of the thermocouple material circuit. The expression for maximum conversion efficiency is given by the following relation, subject to the conditions that optimum A_n/A_p ratio exists and that optimum efficiency match between R_g and R_L has been established:

$$\eta_{g\,(\max)} = \frac{T_h - T_c}{T_h} \cdot \frac{\sqrt{1 + Z\,(T_h + T_c)/2} - 1}{\sqrt{1 + Z\,(T_h + T_c)/2} + \frac{T_c}{T_h}} \tag{11}$$

For best efficiency it becomes apparent from examination of the efficiency equation (11) and the definition of Z (equation 6) that the $k\rho$ product of the thermocouple materials and the cold-junction temperature T_c must be minimized and Seebeck coefficient and hot-junction temperature T_h maximized. Since for most electric conductors and semiconductors, reduction in thermal conductivity is accompanied by approximately proportional increase in electrical resistivity, reducing the $k\rho$ product while maintaining or increasing S is a difficult materials research problem.

Today's practical semiconductor thermoelectric materials, such as the p- and n-type lead tellurides, have $k\rho$ products ranging up to 10 times those of metals. Fortunately, conversion efficiency improves with the square of Seebeck coefficient and inversely with the first power of the $k\rho$ product. Thus, there is a tenfold advantage in semiconductor Seebeck coefficients over those of metals, in spite of the higher semiconductor $k\rho$ products.

Further reference to Fritts is recommended for his broad consideration of p- and n-type lead telluride thermocouple design.

THERMOPILE CONFIGURATION

PHYSICAL ARRANGEMENT of a thermopile structure is primarily dependent upon

1. Heat-source energy density and configuration
2. Radiator absorption capacity and configuration
3. Heat losses and surface transfer rates
4. Mechanical and electrical design feasibility

Heat-source energy density has inherent bearing upon thermopile configuration because of the direct relation between energy density and size of heat source. The heat source must be designed to the thermopile's heat input requirements and should be of the minimum area necesary to accommodate the number of elements of the required L/A ratio in a mechanically and thermodynamically feasible arrangement. It is fundamental that heat insulation losses will be minimized if a maximum of the heat-conducting path from source to radiator is made up of thermoelectric material. Available heat-source energy density and transfer rates to the thermopile hot junctions determine whether or not this ideal can be approached.

Assuming complete coverage of the heat source with thermoelectric material, configuration and type of heat source determine the degree of insulation heat loss to be combated. If the heat source were in the form of a thin slab, it might be covered with close-packed parallel elements having a very short heat-transfer path between elements from hot to cold junction. If the heat source were long and cylindrical, it might be covered with radially arrayed elements which present a small area of nonelement heat-conducting path near the source but increasing with radial distance. A third heat-source configuration is the sphere, surrounded by elements extending to a spherical radiator.

The configuration choice of the thermopile design engineer is, thus, controlled by the factors of feasible heat-source configuration: energy density of source and minimum heat-leakage path.

Considering the spherical configuration concept, and a form of heat energy of given energy density per unit volume, it becomes apparent that a spherical heat-source configuration will contain maximum energy per unit of surface area compared to cylindrical or slab-source configurations. In heat sources where the rate of energy liberation per unit volume is low, a problem of mismatch between high source area and low thermoelectric material area may occur. Any source configuration other than spherical will present greater surface area for the same rate of energy liberation and same energy density.

The insulation heat loss of the spherical concept thermopile is proportional to the mean area A_m of the insulation body. A_m is characterized by the following relation, assuming negligible heat transfer from elements to insulation along their length:

$$A_m = \sqrt{(A_s - A_{tm})\,(A_E - A_{tm})} \tag{12}$$
$$= \sqrt{(\pi D_s^2 - A_{tm})\,[\pi (D_s + 2t_i)^2 - A_{tm}]}$$

where

A_s = Source area

A_E = Insulation exterior area

A_{tm} = Total cross-sectional area thermoelectric material, assuming constant element diameters

t_i = insulation thickness

In the range of $T_t = D_s$ and $A_{tm} = D_s^2/2$, the A_m relation simplifies to

$$A_m = \pi \frac{\sqrt{17}}{2} D_s^2$$

Thus, it is shown for the spherical configuration that insulation heat loss is proportional to the square of heat source diameter in a one-dimensional ratio area of mechanical feasibility.

Similar relationships can be shown for other thermopile configurations, but it may be shown that insulation heat loss for all configurations will vary exponentially greater than unity with heat source size.

HEAT SOURCE DISCUSSION

In the case of combustible fuel sources—whether or not coupled with heat-transfer mediums—uniform hot-junction temperature, combustion efficiency, and flue losses present major problems which can be attacked in four ways:

1. High energy density incandescent combustion system
2. High-temperature closed-cycle condensing-vapor boiler system
3. Flue gas to fuel, air heat exchanging
4. Nuclear-energy heat sources.

The high energy density incandescent combustion system (Fig. 2) is one which seeks to transfer energy to the hot junction by radiation in preference to convection and conduction. Theoretical consideration of this system shows advantages from the standpoints of combustion efficiency, maximum energy density (minimum size), and low thermal inertia. Incandescent sources designed to transfer heat appreciably by radiation offer advantage also in designing for uniformity of hot-junction temperature, a task extremely difficult with gas convection or conduction transfer.

High-temperature condensing-vapor boiler systems (Fig. 3) offer advantages of hot-junction temperature uniformity and high heat-transfer rates at lower temperatures than required by fluid conduction or convection. This may be important in protecting thermoelectric materials which could be damaged easily by accidental overfiring of a direct flame heated thermopile. Temperature uniformity can be obtained by heating the pile with condensing vapor while energy is stripped from the heat source over a fair range of temperature approaching boiler temperature. The problems of closed-cycle high-temperature boilers are primarily those of containing the most probable candidates, such as mercury, protecting against overpressure, and minimizing thermal inertia for control purposes.

In regard to heat exchanging between flue and incoming fuel-air mixtures, greater advantage can be gained if flue gas stack draft can be used to provide the pressure necessary to the exchanger. Since electric power is available at rather low efficiency from the pile, use of electric output for powering inefficient accessories may yield insignificant improvement in over-all efficiency, particularly in small output generators.

The nuclear heat source is one of inherent practicality for thermoelectric generation. Nuclear sources deriving energy from radioactive decay (in the case of isotopes) or fission (in the case of reactors) have no problem of flue-gas loss to hamper over-all efficiency. The nuclear heat source has exceptional watt-hours of energy content per unit weight, compared to all other sources—an advantage for long-life generator service in remote areas, in space, or in locations where air is not available for combustion. The nuclear source inherently minimizes a number of problems for the thermopile design engineer. Since it needs no physical connection with the pile exterior for flue-gas discharge and fuel inlet, heat-conducting members other than thermoelectric material or thermal insulation can be essentially eliminated. The disadvantages of nuclear sources for many ordinary uses are cost and availability. Yet they are indispensable for those uses demanding maximum watt-hours per pound or where periodic refueling is impossible.

Much remains to be known regarding long-term

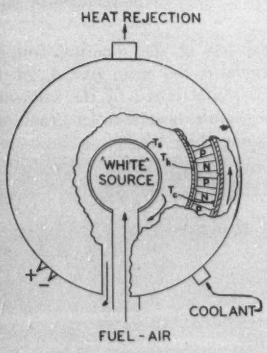

Fig. 2. The incandescent heat source, spherical configuration.

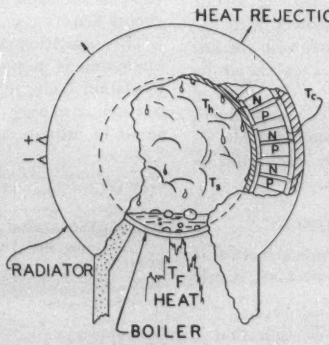

Fig. 3. The closed-boiler condensing-vapor heat source.

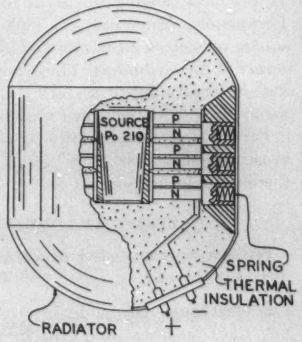

Fig. 4. The SNAP III generator, type 3M-1 thermopile.

radiation effects on semiconductor thermopiles. Insufficient knowledge is available to state effects on all semiconductors, though it had been predicted by Fritts and others that crystal lattice damage should anneal out rapidly at the thermopile operating temperatures involved.

The SNAP III nuclear-fueled generator, reported by Anderson, Barmat, and the author, operated without measurable deterioration of thermoelectric properties since fueled on January 7, 1959, to the present. No great significance can be drawn from this except to note that the source external radiation level was low, very little neutron emission was involved, and no damage of the doped lead telluride elements was expected, nor has it occurred.[3] Significant studies of radiation damage to n and p doped lead telluride materials are now being conducted by a number of firms active in nuclear technology.

DESIGNING WITH SEMICONDUCTOR MATERIALS

PRIME SEMICONDUCTOR MATERIAL FACTORS influencing thermopile design are

1. Stability and strength
2. Contact resistance
3. Sublimation
4. Oxidation and contamination

Designing with materials at elevated temperature involves compromises resulting from the temperature dependency of most material properties. The same problems apply to semiconductor thermoelectric materials in general, though the discussion following is based on the result of experience with p and n doped lead tellurides.

Semiconductors of thermoelectric value are, in general, of brittle nature and poor in tension, but of good strength in compression. Typical physical properties of cast and H_2-annealed doped lead telluride are as follows:

Tensile strength, >1,000 pounds per square inch
Compressive strength, >10,000 pounds per square inch
Young's modulus, 2×10^6 pounds per square inch
Density, 8.15 grams per cubic centimeter
Thermal expansion coefficient, 18×10^{-6} per degree C
Thermal conductivity, 0.02 watt per centimeter per degree C

The strength properties of these materials suggest that the pile structure should be so designed as to limit thermocouple stresses to compression. This compromise imposes limitations, but at the same time aids in the solution of another problem, that of contact resistance.

Contact resistance may be minimized for doped lead telluride materials through the employment of bonded or soldered connections at the cold end and pressure contact at the hot junction. Elements may be formed with integrally bonded contacts for use at either the cold or hot end. However, the difficulty of forming elements with bonded connections at both ends makes engineering consideration of an all-bonded connection scheme impractical at today's state of the art. In usual practice, the cold-end connection is made by soldering of the semiconductor element to a metal contacting cap. The hot-end connection is satisfactorily made by compressively loading the element against the hot-junction connecting shoe shared by its companion element of opposite polarity. Constructions utilizing bonded hot-junction contacts are possible, but unnecessary except where pressure loading is undesirable or inconvenient. Flat-module pile constructions may face mechanical problems in compressive element loading related to the bending strength of the hot- and cold-end plates. In such designs, bonded hot-junction contacts and soldered cold contacts may be exploited to some advantage. Atmospheric pressure contact loading of an evacuated flat pile module may also be exploited, but contacting pressure is limited to values considered insufficient at today's state of the art.

Pressure-loaded elements assure that electrical continuity will be maintained even though some sublimation may occur at the highest temperature portion of the elements. Sublimation may be regarded as an operating life design problem at temperatures in excess of 1,000 F, and although it may be minimized by providing the elements with a coating or cover that restricts diffusion of material away from the hot junction, pressure contacting assures maximum reliability.

The factors of oxidation and poisoning of doped lead tellurides are also temperature-dependent in large degree. Both p and n lead tellurides can be used in extended air-exposed service up to 500 F. However, beyond that point oxidation of the material becomes significant and hermetic sealing is required. Since operating temperatures above 500 F are desirable for maximum Carnot efficiency and the material is capable of stable operation in excess of 1,000 F with long life, hermetic sealing is indicated for maximum over-all efficiency designs.

Oxidation above 500 F may be eliminated as a problem in thermopile design by providing a reducing, inert, or high-vacuum atmosphere within the hermetically sealed enclosure. A reducing atmosphere protects both the element material and all electrical contact surfaces against oxidative degradation. While high vacuum may also provide oxidation protection, it also raises the curve of sublimation rate vs temperature. The increased structural, mechanical, and material problems created by designs which seek to maintain high vacuum over a long life are difficult to solve and costly. High-vacuum environment does have the advantage of lowering losses through most thermal insulation materials which might be used in pile design. However, over-all efficiency gain through use of vacuum is complex and questionable after consideration of the problems of increased sublimation.

Contamination of most thermoelectric materials at elevated temperatures is a problem of which the thermopile designer must be constantly aware. Contamination may result from the diffusion of a number of metals, such as zinc and copper, into the material or from reaction with a large group of active elements and radicals. Diffusion of contaminants into the thermoelectric material results predominately in lowered Seebeck coefficient, whereas reactive contamination

causes increased contact resistance or sublimation rate. The best guide for safety in design is experimental testing of contamination by materials apt to come in intimate contact with the thermoelectric material at elevated temperatures.

In general, hydrogen or methane is desirable as an atmospheric environment for doped lead telluride above 500 F. Such reducing atmospheres serve to protect against oxidation or reactive contaminants that may diffuse in gaseous state to the materials. Materials such as iron, molybdenum, alumina, carbon, and mica are safe for direct contact at elevated temperature. Aluminum, tin, copper, and steel are satisfactory construction materials at the cold end of the pile where solid or gaseous diffusion proceeds at negligible rates. Thermal insulations should, in general, be regarded as suspect until it has been experimentally determined that they are inert at elevated temperatures. Insulation surface coatings or binders may also cause contamination.

THERMOPILE STRUCTURE DESIGN

UNTIL THERMOELECTRIC MATERIALS significantly beyond the present 8 to 11% efficiency range are available, the thermoelectric-device engineer's lot will be one of limited ability to compromise. His first problem today is tolerable output energy cost, and his second is one of heat transfer—too much and too little.

As material conversion efficiencies improve, thermopile design problems decline at a considerably higher rate, particularly those of heat transfer. At the present state of the materials art, 90 to 95% of the heat energy entering the thermopile must be transferred through and rejected for 5 to 10% conversion to electric energy. Thermal design problems and electrical design problems are in the same approximate ratio: 90 to 10. The development engineer's ingenuity is, therefore, taxed in the thermal direction, rather than in the electrical direction, in his quest for maximum practical attainment of today's materials efficiencies. The following discussion is thus oriented:

The Hot End. Regardless of pile configuration, the hot-end problem is one of minimum impedance to heat transfer from source wall to thermoelectric element, in order that source wall temperatures may be kept below safe levels for practical materials of construction. In addition, the element must be electrically insulated from the source (if conductive) and its neighbors, but joined electrically to its companion element of opposite polarity. Solution to the simultaneous problems of low impedance to heat flow and reliable electrical insulation of the interface between element hot-junction connecting shoe and heat-source wall appears best found in the area of high-density vitrified ceramic materials. Heat-flow impedance at this interface is the sum of the interface and insulation thermal resistances. The electrical insulation thermal resistance, proportional to thermal conductivity and thickness, is reduced by use of thin vitreous coatings on the element hot-junction connecting shoes. Also, by use of such bonded coatings, one mechanical interface between shoe and source wall is eliminated.

The pressure contact between element and hot-junction shoe is a lesser problem of thermal impedance not only because it is a single interface, but also because sufficient plastic flow does take place in lead telluride thermoelectric material at temperatures over 900 F to produce mechanically bonded contact to the hot-junction shoe. Reducing atmospheres encourage this bonding by reducing at operating temperature the oxides that may be present on the interface materials. This reduction of interface oxides by reducing atmosphere may be observed in the drop of internal resistance observed in the first few hours of operation of a pressure-contacted doped lead telluride thermopile. It has been noted that the thermal impedances of all the mechanical interfaces between heat source and radiator are lowered by internal gas pressure and raised with vacuum. Gas molecules aid the transfer of heat across dry mechanical interfaces, thus lowering interface thermal impedance.

Between the Ends. As previously considered in the section on configuration, thermal insulation losses can be best limited by covering the source wall area with a maximum of thermoelectric material. Where a match can be designed between thermal watts needed per unit area of element and thermal watts available per unit area, this ideal can be approached according to the ingenuity of the designer in shaping elements for close packing and arranging hot-junction connecting shoes. Usually, the 1-to-1 area match ideal cannot be realized for reasons of configuration, mechanical design feasibility, or cold-end transfer capacity.

The Cold End. Cold-end thermal impedance, like that of the hot end, must be minimized while reliable electrical insulation is maintained between elements and radiator wall. Fig. 4 illustrates one scheme of cold-end design for pressure-contacted elements.

The design of Fig. 4 utilizes a bonded metallic cold-end element contact. This contact member is in mechanical contact with a pressure-applying member which is electrically insulated from the radiator hardware by means of a thin coating. Other schemes of greater or fewer mechanical interfaces may be readily devised, depending on configuration, radiator wall area available per element, necessity of hermetic sealing, and cost. The required features of any pressure contacted element cold-end design are (1) reliable electrical insulation and (2) mechanical flexibility in the thermal path from element to radiator wall sufficient to permit individual element differental movement under spring loading.

The design of Fig. 4 aids electrical insulation reliability by avoiding compressive loading of the electrical insulation. It provides mechanical flexibility in the cold-junction thermal path through the sliding fit between the pressure-applying member and the radiator wall. Thermal impedance of this mechanical interface

is reduced by its relatively large area and a grease-like coating applied to the interface at assembly. Other schemes involving flexible metallic bellows, diaphragms, etc., may have advantages dependent upon obtainable areas, thicknesses, and thermal conductivities of the interfaces, electrical insulation, and hardware involved.

Heat transfer from the radiator wall to the available heat sink is a complex subject which may be attacked in a number of ways with or without liquid or gaseous transfer mediums. Since the transfer rate of all heat transfer methods—convection, conduction, and radiation—is proportional to area, it is advantageous to design for maximum radiator area consistent with other problems. Generator designs for use in space environments face limitations in radiator area and weight. These limitations raise the temperature driving force necessary for the required radiation heat dump rate, with resultant lowering of generator Carnot efficiency. The spherical and cylindrical generator configurations have the inherent advantage of higher external area than flat configurations for the same area of thermoelectric material. The thermopile designer may find it often to his advantage to utilize cylindrical or spherical configuration to ease the problem of cold-end heat transfer, and at the same time benefit from the structural strength, minimum weight, and reduced difficulty of hermetically sealing "round" configurations.

OUTPUT AND CONTROL

THE PROBLEM of output control is essentially one of heat input radiator rejection rate control. The ability to control thermal input varies with type of heat source from moderate for direct fired to not-at-all for nuclear isotope sources. Less variation exists in ability to control heat rejection rates. Also, the problem of thermal inertia in thermoelectric generation at the present state of the art makes output response to load changes sluggish.

Inertia can be reduced by shrinking element size while holding L/A constant for any generator design, provided that source energy density and all heat transfer rates can be increased proportionately. These provisions are increasingly difficult as size of element goes down. Where fast response to load change is needed, the best solution may be found in the use of an electric accumulator between generator and load or by control switching of a reserve portion of the pile to match the load. Like most of the designer's problems, control response will be aided by the reduction of weight which will be made possible by higher efficiency materials.

The difficulty of rapid response control of thermoelectric generators typical of today's state of the art is such that they should be considered best suited to stable or slowly varying loads, except where battery accumulators can be used for instantly available reserve power.

Because of the fact that thermocouples are inherently low-voltage high-current devices, the problem of designing to high-voltage low-current loads becomes difficult. Since high-voltage low-current output requirements lead to high generator internal impedance design, the number of thermoelectric elements goes up and their L/A ratio becomes high. As the L/A ratio goes up, elements become long and thin, thus creating problems of mechanical strength for the designer and making element fabrication difficult. As design power goes up, the problem resolves itself, since most electric power is utilized at under 200 volts, regardless of amperage. It may be stated as a generalization that generator designs for output characteristics of less than 10 watts and more than 10 volts would be simplified, if static d-c to d-c voltage conversion were used to achieve design output voltage. Prospective users of thermoelectric generation at low power levels should consider the voltage problem in their system design and strive for voltage-to-current ratios of less than unity if possible in the 10- to 50-watt ranges.

THE SNAP III GENERATOR

THE SNAP III nuclear-fueled generator, Fig. 4, is a working example of practical thermoelectric generation.[3,4] It utilizes a type *3M-1* thermopile of cylindrical concept built so as to receive a tapered cylindrical isotope (polonium 210) container as its heat source.

Table I. Operational Characteristics of the 3M-1 Thermopile

	Initial*	At Source Half-Life
Thermal input, watts	96	48
Fueling, curies	3,000	1,500
Dose rate at generator surface, milliroentgens per hour	700	350
Dose rate at 1 meter, milliroentgens per hour	7.0	3.5
Hot-junction temperature, degrees F	1,100	720
Cold-junction temperature, degrees F	400	170
Electric output, watts	5.3	2.4
Voltage at maximum efficiency	3.0	2.4
Over-all efficiency, per cent	5.5	5.1
Watt-hours, first half-life = 8,000		
Watt-hours per pound, first half-life = 1,600		

* Estimated; actual fuel load was initially at half-life values.

Since the SNAP III was designed to demonstrate feasibility of thermoelectric power supply for space vehicles, heat rejection is by radiation only. The design of this thermoelectric generator established many of the concepts outlined here. Its operational characteristics are outlined in Table I. Specifications are as follows:

Thermoelectric Element Specifications

Material: p and n doped lead telluride
A_n/A_p ratio: 0.89
L, Element length: 1.0 inches
R_{pn}, Resistance per couple: 0.07526 ohm
E_{pc}, Couple voltage: 190 millivolts
Segmentation: n yes, p no

Thermopile Specifications

T_h, Temperature, hot junction: 1,100 F
T_c, Temperature, cold junction: 400 F
P_o, Power output: 5 watts
V_o, Voltage output at maximum efficiency: 2.8 volts d-c
R_i, Internal resistance: 2.03 ohms
R_L, Load resistance at maximum efficiency: 2.12 ohms
Number of couples: 27
Heat source: polonium 210, 138-day half-life
Diameter: 4.75 inches
Height: 5.5 inches
Weight: 5 pounds

This generator is working proof of practical thermoelectric power. It should be noted that the efficiency attained was the result of a combination of good-efficiency thermoelectric materials, substantial design, and a 100% thermally efficient heat source. The demonstrated efficiency may be debated from the standpoint of economics, but it remains a tribute to those who brought about its existence. This same group has since built and operated an advanced design generator of greater than 7% over-all efficiency.

CONCLUSIONS

THE PROBLEMS confronting the development and design of thermoelectric generators which extract maximum usefulness from today's semimetal thermoelectric materials have been presented. The discussion of these problems serves only to define their probable boundaries. The solutions suggested indicate only that the problems have been attacked, not solved completely.

An example has been given as proof that the concepts defined herein have been reduced to practice and that thermoelectric generation is practical today for many applications which are difficult or uneconomical to accomplish with conventional power-generation methods.

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Analysis of Magnetic Amplifers

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Methods are described for analyzing magnetic amplifier circuits through use of systematic procedures applied to the combination of analytic expressions for the characteristics of the individual circuit elements.

ALTHOUGH THERE ARE MANY methods and procedures for analyzing complex circuits, probably the best-known general approach is to apply an organized, systematic procedure to the combination of the analytic expressions for the voltage–current characteristics of the individual circuit elements. In order for this method of attack to be applied, it is essential that the characteristics of the individual circuit elements, if such elements are definable, can be represented by analytic expressions, and that an organized method exists whereby the analytic representations of the individual circuit elements can be combined to yield the desired result.

Because most practical magnetic amplifier circuits consist of symmetrical interconnections of basic elements, of which the circuit shown in Fig. 1 is a typical example for magnetic amplifiers without diodes, such

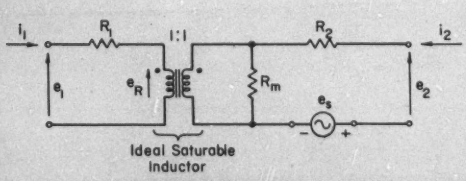

Fig. 1. Basic magnetic amplifier element.

Condensation of two papers, 59-171, "Analysis of Magnetic Amplifiers without Diodes," and 59-172, "Analysis of Magnetic Amplifiers with Diodes," recommended by the AIEE Magnetic Amplifiers Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Scheduled for publication in AIEE *Communication and Electronics*, 1959.

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a method of analysis is particularly useful for magnetic amplifiers.

In the analysis of the basic element shown in Fig. 1, the saturable inductor is assumed to have infinite inductance when unsaturated and zero inductance when saturated. The resistors R_1 and R_2 represent the winding resistances, and the resistor R_m represents the magnetizing impedance of the inductor.

If the supply voltage and the port voltages can be expressed in the form

$$e_s = \sum_{n=1}^{\infty} [a_n \sin n\omega_1 t + b_n \cos n\omega_1 t]$$

$$e_1 = \sum_{n=0}^{\infty} [c_n \sin n\omega_1 t + d_n \cos n\omega_1 t]$$

$$e_2 = \sum_{n=0}^{\infty} [e_n \sin n\omega_1 t + f_n \cos n\omega_1 t]$$

where a_n, b_n, c_n, d_n, e_n, and f_n are constants, and ω_1 is the fundamental frequency of the supply voltage, then the operation of the basic element is periodic of period $1/\omega_1$ second. Thus, the integral of the inductor voltage over an arbitrary period t to $t + T$, where $T = 1/\omega_1$, is equal to zero.

For the magnetic amplifiers of the type considered, the inductor changes state only once per period, and the part of the period in which the inductor is unsaturated is at least half the period. For purpose of analysis, a period of operation is defined as the time interval from t_1 to $t_1 + T$, where t_1 is the instant of time when the inductor becomes unsaturated. This period of operation is then divided into two equal parts, the first part is called the control period and the second the gating period. During the control period the inductor is unsaturated, and during the gating period it is part saturated and part unsaturated. If control- and gating-period average voltages and currents are chosen as variable quantities, then the following equations can be written.

During the control period:

$$\begin{aligned} E_1^c &= R_1 I_1^c + E_R^c \\ E_2^c + E_s^c &= R_2 I_2^c + E_R^c \\ E_R^c &= aE_1^c + b(E_s^c + E_2^c) \\ I_s^c &= I_2^c \end{aligned}$$

During the gating period:

$$\begin{aligned} E_1^g &= R_1 I_1^g + E_R^g \\ E_2^g + E_s^g &= R_2 I_2^g + E_R^g \\ E_R^c + E_R^g &= 0 \\ I_s^g &= I_2^g \end{aligned}$$

where

$$a = \frac{R_m R_1/(R_m + R_2)}{R_1 + R_m R_1/(R_m + R_2)}$$

$$b = \frac{R_1}{R_2} a$$

and where the capital letters with superscript c are used to denote the control-period average values of the quantity denoted by the corresponding lower case letters. Superscript g is used to denote the gating-period average value.

The foregoing equations may be written as the admittance-matrix equation of the network

$$\begin{bmatrix} I_1^c \\ I_1^g \\ I_2^c \\ I_2^g \\ I_s^c \\ I_s^g \end{bmatrix} = \begin{bmatrix} \frac{1-a}{R_1} & 0 & \frac{-b}{R_1} & 0 & \frac{-b}{R_1} & 0 \\ \frac{a}{R_1} & \frac{1}{R_1} & \frac{b}{R_1} & 0 & \frac{b}{R_1} & 0 \\ \frac{-a}{R_2} & 0 & \frac{1-b}{R_2} & 0 & \frac{1-b}{R_2} & 0 \\ \frac{a}{R_2} & 0 & \frac{b}{R_2} & \frac{1}{R_2} & \frac{b}{R_2} & \frac{1}{R_2} \\ \frac{-a}{R_2} & 0 & \frac{1-b}{R_2} & 0 & \frac{1-b}{R_2} & 0 \\ \frac{a}{R_2} & 0 & \frac{b}{R_2} & \frac{1}{R_2} & \frac{b}{R_2} & \frac{1}{R_2} \end{bmatrix} \begin{bmatrix} E_1^c \\ E_1^g \\ E_2^c \\ E_2^g \\ E_s^c \\ E_s^g \end{bmatrix}$$

or simply

$$I = Y_I E$$

The analysis of magnetic amplifiers consisting of interconnections of basic amplifiers reduces to simple matrix addition or multiplication if the proper relationships among the port voltages and currents are used. Consider, for example, the well-known series-connected saturable inductor. This amplifier can be constructed by interconnecting two basic elements of the type shown in Fig. 1 in series–series.

It can readily be shown that the impedance matrix of the interconnected network becomes

$$Z = Y_I + TZ_I T$$

where

$$T = \begin{bmatrix} 0 & -1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

and where Z_I is the impedance matrix of the basic element. If, in general, n identical basic elements are interconnected in series–series, the impedance matrix of the resultant interconnection is given by the expression

$$Z = Z_I + T_1 Z_I T_1 + T_2 Z_I T_2 + \ldots + T_{n-1} Z_I T_{n-1}$$

If the load characteristics and supply source characteristics can be formulated as four linear relationships among the eight variable quantities at the load and supply ports, then the equations stating these relationships can be used with the matrix equation

$$E = ZI$$

to determine expressions for the output in terms of the input.

Protection Against Thrust-Bearing Damage

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DEVELOPMENT of large modern turbogenerators has resulted in reduction of clearances between stationary and moving turbine parts to a bare minimum in order to achieve better turbine efficiency. Because the thrust bearing must be relied upon to maintain these clearances by absorbing any unbalance of thrust in a horizontal direction parallel to the turbine shaft, the importance of its performance has been enhanced greatly. With the older 50-mw class (and lower) units, thrust-bearing failure did not affect the turbine adversely, provided the steam valves were closed immediately after the bearing was wiped. However, with the large, modern, multistage 3,600-rpm units, failure of the thrust bearing usually results in damage to the turbine seals, even if catastrophic damage is prevented by an alert operator.

The transition from low-pressure–temperature turbines to modern high-pressure–temperature turbines has not resulted in a proportional increase in thrust bearing surface area. Experience has indicated that the balance of axial forces is drastically upset under certain abnormal operating conditions on some units. On one type of turbine, experience has proved that if the high-pressure heaters are bypassed without prior reduction in load, a drastic change will occur in the axial thrust because the balance of energy flow through the turbine is upset. Any change in steam conditions can upset the balance similarly and can result in excessive axial thrust. Operating experience at various TVA (Tennessee Valley Authority) steam plants has proved that this condition exists.

This excessive thrust can result in breakdown of the oil film between the bearing runner and the thrust-bearing shoes. The film breakdown invariably is preceded by an increase in temperature that is caused by the initiating increase in pressure.

In the early stages of development of the modern turbogenerators, many people in the industry held the opinion that a thrust-bearing failure could be detected by an increase in the temperature of the oil that leaves the bearing or spindle movement caused by the burning away of the babbitt of the bearing shoe. The operating experience of TVA and other utilities convinced many people that this was not a suitable source of intelligence to protect the machine adequately from the damage that could be caused by a thrust-bearing failure.

Because an increase in thrust shoe metal temperature must precede failure, the initial approach was to install copper-constantan thermocouples connected to recorders in the bearing shoes so that the tip of the thermocouple was in contact with the babbitt. The actual location of the thermocouple was found to be critical. Experimental and empirical data proved that under normal conditions temperature gradients exist between and within the thrust-bearing shoes and that, relatively, this condition does not change as the bearing load changes. This knowledge led to installation of the thermocouples near the trailing edge of the bearing shoe and as close as practicable to the bearing surface.

After it was established that thermocouples installed in the thrust-bearing shoes were mechanically feasible and could serve as a stable, reliable, and sufficiently sensitive source of intelligence, it became apparent that a system of instrumentation should be capable of providing adequate turbine protection, despite the rather narrow bearing-metal temperature range that prevails between normal maximum thrust bearing loading (approximately 160 F) and the upper safety limit (approximately 200 F). Accordingly, a trial installation was made in 1957 on unit 4 at the TVA Kingston Steam Plant. This installation utilized four thermocouples, one in each of two front and two rear shoes, and was designed to trip the turbine throttle valves shut in the event of overheating of one or more of the thrust shoes. The circuit also provided for annunciation to the unit operator before tripping occurred.

For this installation, four special meter relays designed to operate directly off the thermocouples without amplification and equipped with indicating scales were installed on the turbine supervisory instrument board. Each meter relay was adjusted so that its contacts would close at the desired tripping temperature of 200 F within 15 to 20 seconds, as determined by immersing a test thermocouple in a 200 F water bath and timing the response.

Approximately two months after the test installation was completed, the unit was tripped by this device while the unit was operating at reduced load with the high-pressure heaters bypassed. Although it was not determined why the thrust bearing loading increased, tests conducted the following day indicated that the tripping shoes were at a temperature of at least 190 F when the unit tripped.

During a year of continuous operation, the trial tripping device has functioned satisfactorily without revealing any significant deficiencies in the over-all scheme or its components. Based on the results obtained, plans are now under way to install similar devices on additional units to provide protection from thrust-bearing failures.

Digest of paper 58-1151, "Development of Device to Protect Turbogenerators from Damage Because of Thrust-Bearing Failure," recommended by the AIEE Power Generation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Power Apparatus and Systems*, Feb. 1959, pp. 1383-86.

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High-Speed Computer in Turbine–Generator Design

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SINCE 1956, an IBM *704* electronic data-processing machine has been used by the authors' company in the design of large steam turbine–generators. The computer has been an effective aid in both advance engineering and design engineering work for these machines.

In advance engineering, the computer is used in the study of basic problems and in advance design work. A number of computer programs have been specifically written to help engineers solve the complex problems encountered in these areas. Some typical programs are those used to analyze sudden-short-circuit oscillograms and to evaluate the temperature of conductor-cooled rotor windings. Features have been incorporated into computer programs to make them suitable both for special advance engineering studies and for normal design engineering work.

In design engineering, a 3-step plan of computer application is being followed. First, programs are written which analyze each of many aspects of generator design. These programs are relatively simple and, therefore, a library of many such programs can be prepared in a short time. These analysis programs make possible the computer's greatest usefulness by eliminating the time-consuming and repetitious hand calculations which otherwise would be required. In addition to many specialized analysis programs, a general program has been written which makes a complete analysis of a generator design.

The second step of the plan of computer application is to develop programs that determine (synthesize) the design of relatively small components of the generator. These programs may include optimization. This provides an opportunity to obtain experience in this difficult area and to develop techniques that can be applied to large parts of the design determination problem. A few programs of this type have been developed and have been used effectively.

The third step is to develop a program which will determine an acceptable generator design. This step is under development. It represents placing in the program the judgment decisions which the engineer makes at many stages along the way.

The expense of the computer, including rental and indirect expense, is currently $400 per hour of operating time. The expense of doing the required programming is $7 per hour. The programming is done by women who are college graduates in mathematics. They are responsible for all the nonengineering aspects of the job.

In addition to the engineering time required, the cost of a computer program is the sum of the costs of the programmer's time, computer checking of the program, and computer operating time. Cost data for the design-analysis program are representative of computer programs used in design work. Based on present costs, the programming expense was $4,800 and checking by the computer cost $2,800. Each computer run costs $2.65.

The design analysis program has been used an average of 3.1 times per working day since June 1956. The total cost of preparing and using the program has been approximately $12,000. The incremental cost of a computer design run is equivalent to approximately 20 minutes of engineering time, including overhead. To this must be added the engineer's time of 5 to 10 minutes required to provide the input data for the program, and 5 to 10 minutes to check the output for reliability. Thus, an equivalent of 30 to 40 minutes of an engineer's time is all that is required to make one run of the design analysis program.

The engineer who regularly uses a large high-speed computer as an intimate part of his work finds that he must so organize his work habits that the computer can become an efficiently used part of his work cycle. The time delay in obtaining the computer results should be planned for so that the engineer can effectively pick up the thread of a job when he receives results from the computer.

Providing input to the computer and using its output are the largest potential sources of error. Many features have been incorporated into computer programs to make them easy and reliable to be used by a group of engineers. These features include a carefully planned format for input data, a list of preferred items of input data, easy-to-understand input instructions to the computer, clear identification and effective arrangement of printed output of the desired results, and a printing out of sufficient intermediate results to provide the engineer with the information necessary to check the computed results.

The computer has become a necessity. It has value beyond that measurable in terms of dollars. It makes possible a more complete understanding of machine design and behavior. Its value can be measured in part by the extent to which it permits a designer to improve designs. The computer is an essential factor in a number of studies which are expected to result in improved generator performance and reduced size. The value of having calculations made quickly, accurately, and consistently is difficult to measure, but the resulting gain to the engineering operation is improved effectiveness and service.

Digest of paper 58-1089, "Experience in Using a High-Speed Computer in the Design of Large Turbine–Generators," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Power Industry Computer Application Conference, Toronto, Ont., Canada, Sept. 15-17, 1958. Published in AIEE *Power Apparatus and Systems*, Feb. 1959, pp. 1230-36.

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A Program in Engineering Science for all Engineering Students

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A program of undergraduate engineering education built around a core of courses that stress the fundamental understanding of engineering sciences for all students. It is hoped this program modification will foster the creative ability necessary to meet the demands of our increasingly complex technological society.

MUCH has been written and said about the pressing need for a modification of undergraduate engineering education toward the direction of fundamental understanding of engineering science and the ability to use this science creatively in engineering situations. Many outstanding engineers, scientists, and engineering educators have come to consider this point as a most crucial issue in the progress of our technological society.[1] A serious and very valuable effort was put forth on this subject by the American Society for Engineering Education (ASEE) in its Report on the Engineering Sciences[2] and Report on Evaluation of Engineering Education.[3] It is not the purpose of this paper to re-discuss these objectives but rather to embrace them wholeheartedly and describe a program which has evolved through the consideration of these reports and much self-study.

The School of Engineering at the University of Wichita, Kansas, is instituting in September 1959, a new program comprised of a core of all university, all engineering, and department requirements. This program contains a core of courses in engineering science which are required for all engineering students and which form a background on which the departments may build. Among this core of courses are some rather radical departures from the more traditional engineering education. These departures are in the direction of unifying certain subject matter which has previously been relegated to the various departments with little or no cross-fertilization. In addition, there are certain departures which pertain not to subject matter but rather to the proposal that an engineer should be educated so that he is not only knowledgeable in associated engineering specialties, but has a reasonably high degree of mastery of these associated areas. Thus, it will be seen that the required breadth and depth of understanding is extended to areas that are presently foreign to many curricula.

A special article recommended for publication by the AIEE Educational Publications Committee.

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The development of this program has been the work of the entire engineering faculty at the University of Wichita. Particular acknowledgement should be made of the efforts of Dean Kenneth Razak and Assistant Dean M. H. Snyder who have figured so prominently in the formation of many of these ideas.

OUTLINE OF THE PROGRAM

FIG. 1. SYMBOLICALLY SHOWS the structure of the over-all program. The general university core requirements were adopted by the entire university and specify areas of study required by all students. These requirements were evolved by an intercollege committee and reflect a philosophy of general education to "develop as fully as possible the potentialities of every student as a person and as a citizen," while attempting to reconcile the valid needs of the professional schools. This segment occupies about one third of the total program, but a portion of normal engineering mathematics and science is included.

The engineering core courses are required of all engineering students and constitute about one half of their program. These are not all engineering courses as such, but include mathematics and basic science. Actually, 49 credit hours (34% of over-all program) are in engineering and these courses deal with the material called Engineering Science by the ASEE committee.[2]

Only about one sixth of this program specifically pertains to any departmental specialty; the diagram shows those departments now in existence at Wichita. Inasmuch as it was felt that other departments might be added at a later date, the engineering core program was planned so that it would also serve any new engineering departments which could be foreseen.

THE ENGINEERING CORE PROGRAM

WHEN STUDY WAS INITIATED on this program, certain objectives and ground rules were decided upon, in the light of which the program must be evaluated. They are:

1. Endorsement of the conclusions and recommendations of the ASEE Report on Evaluation of Engineering Education[3] and a pledge to carry them out as fully as possible within the framework of the local situation.
2. Retaining departmental degrees as opposed to a degree in engineering without specialization.
3. Retaining a 4-year program with 144 credit hours required for any engineering degree.
4. Instituting a "core" of courses in fundamental engineering science rather than having the familiar "service" course for nonmajors in a particular field.

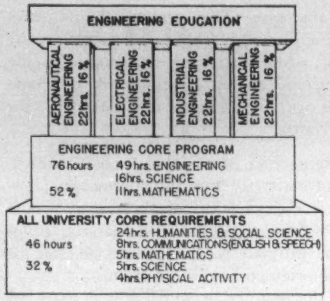

Fig. 1. Structure of the engineering program.

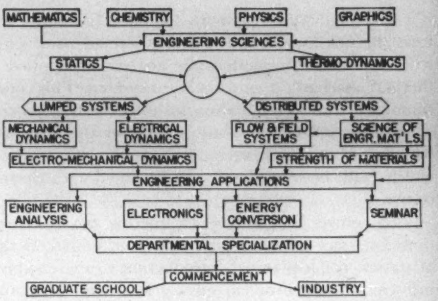

Fig. 2. Engineering core program.

This set of courses will be required of all engineering students and the philosophy of the organization and teaching of these courses will be such that the courses will be satisfactory for a student majoring in each department without later retracing his steps because of a previous preparation which was not sufficiently fundamental.

5. Because of the pressure of time, it is necessary to be as efficient as possible in the presentation of fundamentals and still accomplish sufficient understanding to form a background which has a lasting effect. In order to obviate this difficulty, emphasis will be placed upon unity of the engineering sciences and similarity among the various fields of application.

Objective No. 4 is a commitment to the principle that, if necessary, we will restrict ourselves to doing a complete job on what is attempted rather than a hurried survey of an entire field. In this way, any department can take up where the core course terminated, presumably being assured that the fundamentals have been well laid. The following quote, which is taken from p. 91 of the Report on the Engineering Sciences,[2] supports this philosophy:

> "The function of the undergraduate engineering program is the establishment of the bases for future learning and problem solving activity, not the conveying of factual technological background."

The approach of objective No. 5, which emphasizes the unity in the engineering sciences, has been brought out before by many authors. The ASEE Report[3] states this clearly on p. 35. Others[4] have recognized the power to be gained by a complete understanding of the conceptual relationship of seemingly diverse physical fields.

The program which evolved from these objectives is shown schematically in Fig. 2. The basic sciences form the background for an introduction to engineering science, thought processes, and problem solving in the statics and thermodynamics courses. After this, at the beginning of the junior year, the program follows two main stems in parallel: the areas of lumped systems and distributed systems. These main stems merge in the engineering applications which are in both core courses and department courses. This division is made only to show the main areas of interest. It is not intended to indicate that there are no applications in engineering science courses nor that there is no engineering science in the courses listed under applications.

The engineering core courses will now be discussed in some detail. This discussion will emphasize those areas where the program is a departure from more common programs. No slighting of the other areas is intended since it is felt that all areas are very important. Those courses not discussed in detail are generally familiar to most engineers and, thus, will not require detailed explanation.

COURSE DESCRIPTIONS

Engineering Graphics—(5 credit hours). There are three courses in this division. These courses give the student a background in engineering drawing, and, in addition, put emphasis on: (a) graphical presentation of data and relationships given by equations; (b) graphical calculus, nomography, and computation; and (c) graphical resolution and composition of vectors. It should be noted that these courses occur concurrently with calculus and before statics. Thus, they afford a reinforcement of mathematics and an introduction to later engineering work. The problem-type approach is to be used as a teaching method and utmost use is to be made of the student's mathematical and scientific maturity.

Statics—(3 credit hours). The course content treats mechanical statics from the vector viewpoint, but also covers the areas of electric circuit statics (d-c circuits) and fluid statics. Similarities between Newton's Laws for the static case and Kirchhoff's Laws will be stressed. This course is intended to serve as an introduction to the engineering sciences, particularly as an introduction to engineering problem solving.

Both lumped and distributed systems are treated in this course, and time will be spent to consider the distinction and overlapping of these two areas which form the two branches of the program in the junior year. Considerable emphasis also will be placed on work and energy ideas, including a generalized treatment of the principle of virtual displacement. Thus, this course should integrate with the thermodynamics which the student takes concurrently.

Thermodynamics— (3 credit hours). This course will treat the first and second laws of thermodynamics and will emphasize thermodynamic analysis as applied to thermal, mechanical, and chemical systems. This course should lay a solid foundation for the fluid flow portion of the flow and field systems course and also serve as a basis for a broader treatment of energy transformations which will be considered in the energy conversion course.

This course, in addition to treating the aforementioned subject matter, serves a purpose similar to that of statics; i.e., a planned introduction to the engineering sciences and problem solving activities. The problems to be treated will occasionally overlap into the electrical, nuclear, and light fields, thus illustrating the generality of thermodynamic analysis. A more general consideration of the broadness of the method will be handled in the energy conversion course.

Mechanical Dynamics— (3 credit hours). This course will deal with the laws of motion and the dynamics of particles, rigid bodies, and systems of particles. The methods of vector and analysis (time derivatives only) will be used. Some problems will be taken from other fields such as electron motion, viscous effects, etc.

Electrical Dynamics— (4 credit hours). This is electric circuit analysis with emphasis on the sinusoidal steady-state. The integrated laboratory which accompanies this course deals with student performed laboratory problems requiring the exercise of initiative and analytical thinking.

Electromechanical Dynamics— (2 credit hours). This course is taken in the second semester of the junior year and follows the two previously described dynamics courses. It is intended to accomplish an integration of the methods of analysis of electrical, mechanical, and combined linear systems. Fig. 3 shows that the coverage emphasizes classical solution of transient response for both the fields of electrical transients and mechanical vibrations. The analogies of electrical and mechanical systems are pushed to the forefront and a first effort is made at showing the relationship between transient and frequency response (the electrical engineering students will have much more of this in their departmental program).

Analog simulation also is covered as a vivid illustration of these analogies. The student should have acquired the principles of operation and programming to the extent of actual beginning competence in the use of the electronic analog computer. A desk-type analog computer will be available to all students for this part of the course.

Science of Engineering Materials— (5 credit hours). This is a study of materials from the microscopic viewpoint leading to a description of their macroscopic properties. Engineering application of material properties will be the ultimate goal, of course, so that all discussion will be oriented in this direction.

Fig. 4. shows the manner in which this description will proceed. The viewpoint will be that of solid-state physics and the student will simultaneously be exposed to both physicist's and engineer's viewpoints, because he will be concurrently enrolled in a course of modern physics. It is intended that the level of treatment be that of the book by Goldman,[5] although this book will not cover the course as planned.

A list of some of the properties of materials to be considered will indicate the coverage: viscosity; thermal conductivity; electrical conductivity; crystallic imperfections; phase equilibrium (alloying) and phase changes; para-, dia-, and ferromagnetism; dielectric polarization and strength; semiconduction; modulus of elasticity; impact, fatigue, creep, and relaxation; plasticity; etc.

This will be a particularly difficult course to teach, because it will be necessary to present some semblance of order to the basis for these properties and yet keep the course from becoming a hodgepodge of material to be learned by rote. However, it is felt that this material is necessary in order to give a perspective to the student of the diverse and sometimes mysterious properties of materials and the way these properties are exploited by engineers. Much of the content covered will be used and reinforced in practically all succeeding core and departmental courses.

A laboratory period will be an integral part of this course and will include many demonstrations as well as student performed laboratory problems. Emphasis will be put on creative use of the material properties in engineering situations rather than a perfunctory verification of classroom material.

Flow and Field Systems I and II— (8 credit hours).

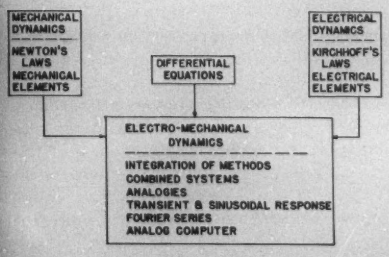

Fig. 3. Electromechanical Dynamics.

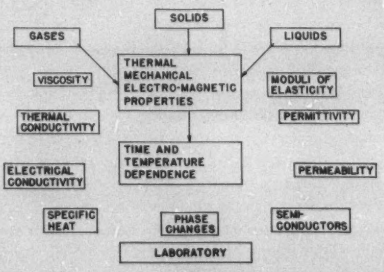

Fig. 4. Science of Engineering Materials.

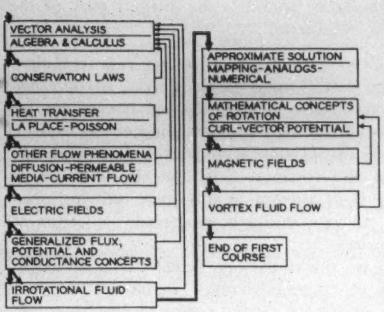

Fig. 5. Flow and Field Systems I.

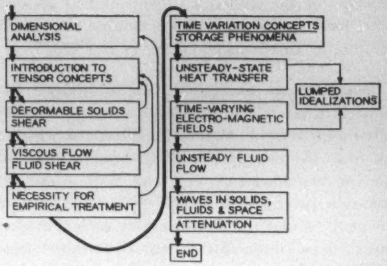

Fig. 6. Flow and Field Systems II.

This is a 2-semester sequence which deals with those systems in which the quantities of interest vary in space. An integration of a large number of subject areas is proposed here with the basis for the integration being the strong mathematical similarity which exists in these seemingly diverse fields.

Fig. 5 shows the outline of the first semester and indicates, as well, some of the teaching methods to be used. The intention is to use what might be called a helical approach in showing places where many of these areas have a common mathematical foundation. The student will not have had any mathematics courses which treated vector analysis, so that this course will start at that point and develop vector calculus through the concepts of gradient and divergence. Potential concepts will be stressed. This will be a short initial exposure to these ideas but should be rather fundamental. The student will turn to an immediate application of these concepts in some general consideration of the conservation laws of matter and energy. Then, heat transfer will be considered, because this gives a simple but practical example of the use of these ideas. The student will solve the LaPlace and Poisson Equations for one-dimensional geometry (rectangular, cylindrical, and spherical geometry when symmetry exists).

Continuing as in Fig. 5, each topic is introduced by returning to the mathematical basis and reviewing the previous applications with the hope that a real understanding of the significance of these interrelationships will be acquired. Thus, when the phenomena of diffusion, flow-through permeable media, and flow of electric charge are examined, the previous use of the conservation of matter will be stressed and its extension to conservation of electric charge will be a small step. Each of these processes may be described by a transfer law which expresses a flow quantity as being proportional to the gradient of a potential quantity. In each of these, application of the divergence theorem yields similar results and one obtains LaPlace's equation or some modification of it depending on the particular problem.

When a more serious consideration of electric fields is reached, the groundwork has already been laid for an immediate consideration of a vector field strength quantity. Electric flux density (electric displacement) can readily be shown to be analogous to the flow quantities previously considered, although the flow concept is more abstract here.

The areas of irrotational fluid flow are but a slight extension of the previously developed concepts, and heavy use can be made of the mathematical similarity. The concept of the stream function can be introduced at this point and one can return to the older material to show that it could be used there also.

The remainder of these courses will not be covered in detail, but it is possible to conjecture how similarities can be illustrated in the fashion which was previously discussed. Fig. 6 shows the outline of the second semester, the first part of which is a continuation of the first semester in areas where tensor concepts are essential to an understanding of shear phenomena. The class then considers time variations and returns through much of the previous material looking at the modifications required. The course ends with an introductory treatment of waves from the viewpoint of solutions to the wave equation.

It is to be emphasized that the student will be asked to work engineering problems along with each subject. In this way the student should be encouraged because, at each stage, even though the theory is not developed in its full glory until late in the courses, he has learned something of immediate value which has application to significant engineering situations.

Two 2-hour laboratory-computation periods will be associated with each semester. These periods will be used for the giving and discussing of examinations, supervised problem-solving, demonstrations, and student performed laboratory problems. A complete set of laboratory equipment will be developed for this area. The electrolytic tank, conducting paper board, flow table, analog and digital computer aids, traveling wave demonstrators, etc. will be used both in demonstrations and by students.

Strength of Materials—(5 credit hours). This course deals with theories of stress and strain and the analysis of structural elements. It builds on previous subject matter given in statics, science of engineering materials, and the second semester of flow and field systems in which deformable bodies are considered. A laboratory period is included. It is thought that it will be possible

because of the student's background to include certain concepts which have been commonly considered to belong in an advanced course of this type.

Engineering Analysis— (3 credit hours). The major objective of this course is the development of the student's capacity to deal with situations which are new to him, by the application of fundamental principles, on his own initiative, and with well-ordered analytical thought processes. It covers the area of design as well as analysis and the problems are such that the student must draw upon his previously studied engineering science. However, these fundamentals have to be applied to situations which are new to him and in which it is not at all clear just what the real problem is. The student is required to use original thinking, exercise of judgment, and to make decisions in order to handle these new situations. There is no space here for a general development of the course philosophy which can only be done by example. This concept has been well developed and the reader is referred to the book by Ver Planck and Teare[6] and the ASEE Committee report on engineering analysis and design.[2]

Although it is expected that all courses which the student takes will be taught in a manner in which fundamental understanding and the development of problem solving ability are emphasized, it is felt that the student's capacity to treat new situations with good professional style will be greatly increased by a course such as this one. It is recognized, after all, that the final objectives of the other courses are comprehension of subject matter dealing with new principles and new techniques so that it is reasonable to have a course where little or no new subject matter is introduced but the student spends his time with the method of problem solving through practice.

Electronics— (4 credit hours). This course is unique in that it is being required of all engineering students. Thus, it attempts to lay a good foundation for those who are to go on in this area, as well as for those who will do little more formal study in electronics.

Fig. 7 shows the topics to be covered. It can be seen that it will be possible to give only brief consideration to the enormous field of applications in the time available. A laboratory period is an integral part of the program in electronics.

Energy Conversion— (3 credit hours). It is recognized that a large part of engineering practice is concerned with the exploitation of materials and phenomena for the purpose of causing and controlling energy conversion. This industrial effort is not restricted to traditional engineering departmental lines and the objective of this course is to attempt to introduce unifying principles and concepts into a heterogeneous collection of physical devices.

In one sense, this course may be considered an extention of basic thermodynamics inasmuch as it is essentially concerned with energy transformations. However, in another sense, it may be looked upon as the culmination of the study of the various background material previously discussed. In any event, it is concerned with the study of the principles of energy conversion and an illustration of these principles in the operation of energy transducers of all kinds. In addition, a secondary value will accrue to the student from the contact he has made with certain devices which will give him some sense of familiarity with the field in its present state.

Fig. 8 indicates the areas to be considered and, as can be imagined, there is an imposing list of devices and processes (existing or proposed) which can be made for all these transformations. Some of the areas which we wish to include are listed in Fig. 7 of the paper by Brown, Kusko, and White;[7] but, as opposed to that list, we do not wish to limit this to energy conversions concerned only with electrical energy.

A partial listing of some of the devices and phenomena which might be treated will indicate the scope of outlook: chemical battery, solar battery, electroluminescence, turbines, jet engines, pumps, magnetostriction, motors and generators, magnetohydrodynamics, ion propulsion, electromagnetic pump, thermopiles, semiconductor refrigeration, nuclear fission and fusion reactors. It can be seen that no detailed study can be made of any one of these devices but it is not intended that this course be a survey course in the sense that the student will be called upon to do significant problem work which will involve practically all of his

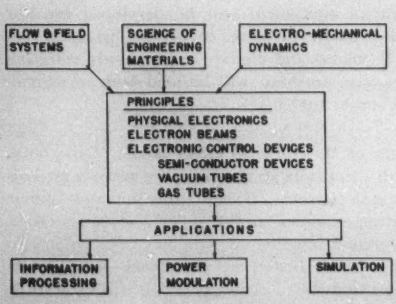

Fig. 7. Electronics.

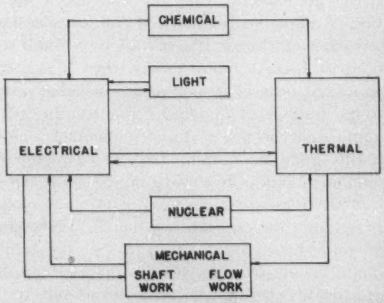

Fig. 8. Energy Conversion.

previously studied fundamentals. In addition, it is proposed to discuss areas which are not yet completely developed, such as the nuclear-electrical conversion process in the presently researched fusion reactor, or the areas of magnetohydrodynamics. It may be seen that the viewpoint of this course is in keeping with the philosophy stated by the ASEE Committee on Thermodynamics.[2]

Seminar—(1 credit hour). The student will participate in group problem-solving activities for the first part of the semester. The second part will be devoted to oral presentation of papers which have been written by the student on some field of current interest in the engineering profession.

DEPARTMENT PROGRAMS

EACH DEPARTMENT will have 22 credit hours in which courses may be specified for students interested in pursuing some particular field in more depth. These department courses will build on the core program and will give opportunity for engineering analysis, study of engineering systems, and design using the engineering science fundamentals provided by the core courses. In general, the department program will start in the second semester junior year with one course, with the rest of this program limited to the senior year. In addition, it is planned eventually to have a program in engineering science for those students who do not wish to specialize as restricted by the department requirements.

IMPLEMENTATION

IT IS CLEARLY RECOGNIZED that a major effort will be required for the implementation of this program. Faculty education in subject matter is necessary to obtain a continuity in teaching. Sufficient time must be given to the faculty to develop course syllibuses, teaching aids, and laboratory equipment more fully. In some of these courses, there is a serious problem with textbooks, because there do not seem to be any books available with the required outlook and emphasis. This means mimeographed notes must be developed by the faculty with published texts as the eventual aim.

The University of Wichita proposes to accomplish these aims by making time available to the faculty during the summer vacation periods and, to a lesser degree, during the regular semesters. The first few times these courses are taught, it will be necessary to lighten teaching loads. A long development period will be required before the program reaches its full growth.

SUMMARY

THE PROGRAM PRESENTED HERE is one which emphasizes the engineering sciences and stipulates a core of courses in this area which are required for all engineering students. Unity and similarity among the various fields is the underlying philosophy which has determined the organization of these courses. The department requirements play a smaller role than previously, but, inasmuch as the department courses have a strong engineering science background on which to build, it is felt that the over-all effect is a desirable one. It is believed that the significance of this program lies in the fact that it applies to all engineering students.

It is most certainly true that the determining factor will be the manner of teaching; for no matter what the organization of a program may be, the quality of the graduates depends upon the attitude of the teachers. Since the program is not yet instituted, only the mellowing light of time and experience will show the ultimate value of this undertaking.

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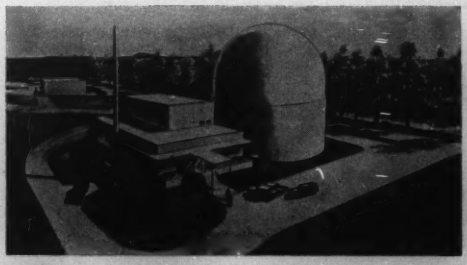
Ohio Atomic Power Plant

Shown at the right is an artist's drawing of the nuclear power plant being built for the City of Piqua, Ohio, by Atomics International, a division of North American Aviation, Inc. An organic cooled and moderated reactor will provide heat for the generation of 11,400 net electric kw. The power reactor will be located beneath the spherical dome (*at the right*), with support equipment, control room, and offices in the adjacent building. The Piqua plant, scheduled for completion in 1961, is part of the U. S. Atomic Energy Commission's power reactor demonstration program.



Transmission Line Switching Surges

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E. R. TAYLOR, JR.
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RECENT IMPROVEMENTS in arrester impulse protective levels have permitted the application of power apparatus having insulation reduced two voltage classes on well-grounded systems where 75% or 80% arresters can be applied. Although the insulation of such apparatus can be adequately protected against impulse voltages, the adequacy of lightning arresters to protect the reduced insulation against switching surges is not so well established. Some of the areas receiving increased attention by the electrical industry are:

1. Determination of magnitude, wave shape, and duration of switching surge voltages.
2. Establishment of the insulation strength of apparatus subject to switching surge voltages.
3. Determination of the duty that arresters will be subjected to in providing protection for apparatus when exposed to excessive switching surge voltages.

This digest is primarily concerned with areas 1 and 3, and shows the results of a study of a miniature system representation on the ANACOM (analogue computer). Saturated characteristics of transformers were provided by saturable cores in series with linear air core inductors, and the unsaturated characteristics by the combination of miniature transformers and saturable cores in parallel. The specific types of switching surges investigated are those resulting from dropping a long, high-voltage transmission line with a modern circuit breaker, with a maximum of one restrike during interruption.

In order to evaluate the effects of generator and transformer sizes and characteristics, line length, and arrester operations upon voltages that result from breaker restriking when dropping a line, the investigation was divided into four separate studies.

Study 1—Dropping an Open-Ended Line. In this study, line lengths of 100, 200, and 300 miles at 345 kv were used. For each line length, the generator and sending-end transformer ratings were varied from 220 mva to 880 mva. This range of mva ratings shows the effects of varying the source inductance.

Study 2—Dropping an Open-Ended Line with Arrester Operation. With the previous conditions given in Study 1, 80% arrester operations were simulated at the ends of the line. Sparkover of each arrester was 2.7 per unit of crest normal line-to-neutral sending-end voltage.

Study 3—Dropping a Line with Receiving-End Transformer Only. With the addition of transformers connected grounded Y-delta on the end of the line, a path is provided for the modification of the trapped voltage on the line following the initial breaker opening, and for the transfer of energy between phases. Voltages that result from dropping a 100- and 300-mile line with a receiving-end transformer were studied.

Study 4—Dropping a Line with Receiving-End Transformer and Arrester Operation. For the 310-mva transformer on the end of the 300-mile line and low-voltage level, the "C" phase was restruck to give the maximum voltage on the "A" phase at the sending end. A 75% arrester operation was simulated on the "A" phase at the sending end, sparking over at 1.5 times the crest of the maximum arrester a-c voltage rating.

A summary of the magnitude and duration of switching surge voltages along with the arrester currents are given in the following paragraphs.

1. Switching surge voltages without modification by arrester operations or transformer characteristics were in the range of 3.1 to 3.4 per unit of crest normal line-to-neutral sending-end voltage. Times to crest increased with line length and ranged from 2,000 to 8,000 microseconds.

2. For the arresters assumed in this study, bus voltages were never high enough to cause arrester spark over. Arrester operations on the ends of the line with no receiving-end transformer resulted in crest arrester currents of 550 to 800 amperes and maximum discharge voltages of 1.8 to 2.1 per unit for the line lengths and source sizes studied. Duration of arrester currents increased with line length from approximately 1,100 to 3,300 microseconds.

3. When dropping a line with a transformer at the receiving end, maximum magnitudes of voltages on the line as a result of switching surges were lower, ranging up to 2.8 per unit of sending-end crest line-to-neutral voltage. Higher voltages resulted at the sending end than did at the receiving end. In general, receiving-end crest voltages were lower than sparkover for the arresters considered in this study. Lower voltages were obtained when working the transformer iron closer to the saturation point since lower breaker voltages were available for restrike.

4. Where arrester operation was simulated with reduced sparkover and with the receiving-end transformer on the line, a lower crest magnitude of arrester current, 380 amperes, resulted, but the duration approached 10,000 microseconds. The receiving-end transformer provided a path for the transfer of switching surges between phases. As a result, the arrester discharge current could be extended.

Digest of paper 58-1216, "Transmission Line Switching Surges as Modified by Transformer Impedances and Arrester Operation," recommended by the AIEE Transmision and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Power Apparatus and Systems*, Feb. 1959.

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Auxiliary Power for Eddystone Station

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TWO 325,000-KW turbine–generator units operating at supercritical steam pressures are being installed in the new Eddystone Station of the Philadelphia Electric Company. The station is located southwest of the center of Philadelphia, near the city of Chester, Pa. The higher steam pressures involve greater auxiliary power requirements than usual, but the use of steam turbine driven high-pressure boiler feed pumps reduces the portion carried electrically to about the normal percentage. To achieve adequate reliability in the auxiliary power system and, at the same time, to provide an economical design has been a primary objective. Simplicity of layout with a minimum number of cross ties and the absence of complicated automatic throwover schemes contribute to this result. Furthermore, the electric system has been co-ordinated with the mechanical requirements to obtain a balanced design.

Auxiliary electric power requirements are approximately 28,000 kva for the first unit and 26,000 kva for the second unit. Fig. 1, which is a single-line diagram of the station, shows the 4-kv auxiliary power system.

The basic factors which entered into the design of the auxiliary power system are the following:

1. The essential auxiliaries for each unit are supplied from the unit with which they are associated.
2. The common plant equipment, such as coal handling and ash removal, and general plant services are supplied from a separate station auxiliary power system.
3. Starting capacity and emergency supply are obtained from the station auxiliary power busses.
4. No capacity is included in the auxiliary system of one unit to supply or start the second unit.
5. The auxiliary power system for each unit and the station auxiliary power system are radial systems.
6. No automatic transfer is provided for the main unit auxiliaries, except for combustion control equipment. On loss of oil pressure, bearing oil, Sulzer control oil, and hydrogen seal oil pressures are maintained automatically from emergency pumps.
7. Maximum simplicity of design consistent with reliability of operation has been maintained.

Each unit auxiliary power system is supplied by two 16,000-kva transformers as shown in Fig. 1. The 4-kv busses shown are located in turbine hall, the boiler house, and the screen house. From these busses, sealed-dry-type transformers step the voltage down to 440 volts or 208Y/120 volts for supplying the smaller motors and other auxiliaries. The use of two transformers and two sets of busses increases the reliability and also permits the use of 250-mva interrupting capacity 4-kv circuit breakers. The auxiliaries are divided between these busses so that loss of any one bus will not prevent operation of the unit, although operation will be at reduced capacity.

The two station auxiliary power busses are supplied from the 132-kv busses through 20,000-kva transformers. Each transformer has capacity for the station auxiliary power requirements and also for starting a main unit. In addition, it can be used in the event of failure of one of the unit auxiliary power transformers to supply the set of busses affected. From the 4-kv busses, feeds supply 4,000-440-volt transformers located throughout the plant for common station auxiliaries and 4,000-208Y/120-volt transformers for lighting.

The station auxiliary power system was greatly simplified by the development of the 3,000-ampere 4,160-volt 350-mva interrupting capacity magnetic air circuit breaker. Three of these were used, two for the station auxiliary power transformers and one for the tie between the two station auxiliary power busses.

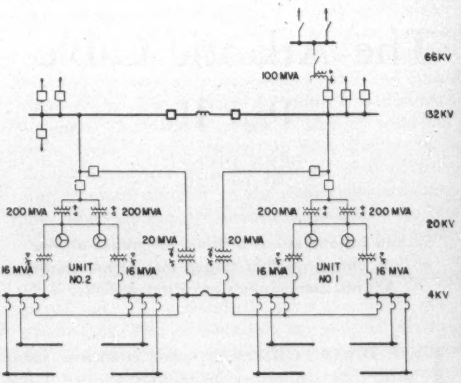

Fig. 1. Single-line diagram of station, including 4-kv auxiliary power system.

For generator faults, all lines and equipment connected to the associated 132-kv bus are tripped in order to maintain system stability. To prevent loss of the related 4-kv station auxiliary power bus when this occurs, the 4-kv tie breaker closes automatically to supply this 4-kv bus from its counterpart fed from the second 132-kv bus.

Digest of paper 58-1107, recommended by the AIEE Power Generation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE–ASME National Power Conference, Boston, Mass., Sept. 29–Oct. 1, 1958. Published in AIEE *Power Apparatus and Systems*, Feb. 1959, pp. 1324-29.

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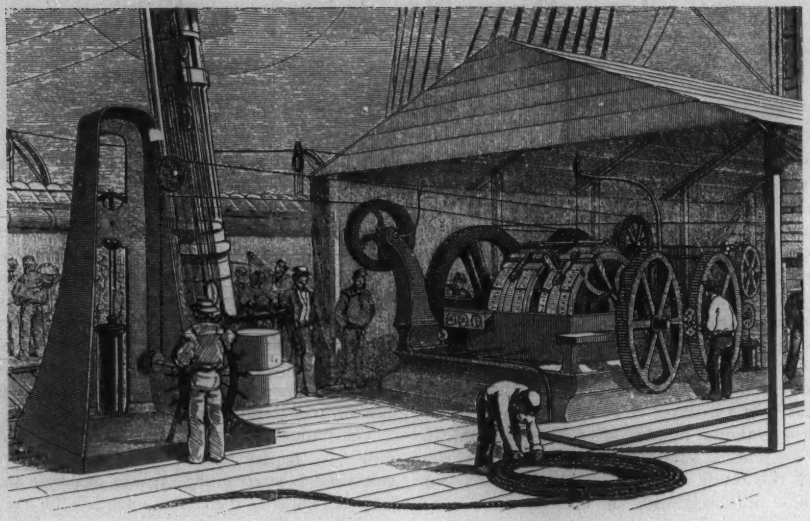

The cable issuing machine on the stern of the *Niagara*, as installed by William Everett. Designed to pay out and hold as much as 5 miles of suspended cable, the brake drums revolved in cooling water. The dynamometer, (*left*) indicated the cable strain. A similar machine was on the *Agamemnon*.

The Atlantic Cable

Part II

BERN DIBNER
FELLOW AIEE

Second installment of a three-part series on the historic enterprise that forged one of the North Atlantic community's most potent links.

THE DIRECTORS of the cable enterprise spent little time deploring the failures of their latest expedition. Having determined to try again, no time was lost in getting on with the task. By mid-July, all the vessels had returned to England and busily took on supplies of coal, food, and other essentials needed for the new voyage.

THE SECOND EXPEDITION OF 1858

ON SATURDAY, July 17th, the squadron left Cork for a rendezvous in the mid-Atlantic.

No time was lost when the squadron met at their appointed mid-ocean location. The cables were spliced aboard the *Agamemnon*. A 32-pound cannonball was commandeered to replace the lead sinker which had fallen overboard. It was fastened to the splice to help in its immersion and the midsection began its downward journey. When the splice reached a depth of 210 fathoms, the hawser connecting the *Niagara* and the *Agamemnon* for the splicing operation was cut, and the two vessels started toward their opposite destinations. The depth at the midpoint was sounded to be 1,500 fathoms. Field had determined that Valentia harbor was 813 nautical miles from this point and, westward, Trinity Bay lay 882 nautical miles away. The *Niagara*, facing westward, had 69 miles more to cover than the *Agamemnon*, then heading for Ireland. Each ship had 1,100 nautical miles of cable on board. As the ships parted there was a tenseness on board with only Field expressing his usual confidence to his companions on the *Niagara*. At about sunset of this first day out, there was a sudden break in the signals coming from the *Agamemnon* although the insulation showed no breakdown. Electrical testing, however, continued and after an hour and a half the *Agamemnon* again responded. The cause of the break in signals was not determined, but was probably a break in the battery circuit on the *Niagara*.

The next day there was another cause for alarm. On checking position it was found that the *Niagara* had moved some 16 miles off her course as indicated by the sextant and log. Such a percentage of loss meant that the cable could not last the required distance to Newfoundland. On further careful checking it was discovered that it was the mass of the iron forming the cable covering stored in the ship that had affected the compass and a correction in course had to be made. This was done by having the *Gorgon* proceed ahead

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"The Atlantic Cable," book, published by Burndy Library, 1959.

of the *Niagara* and, thus, set the course. Not having the mass of iron in the cable aboard, her compass was not affected. No other major incidents disturbed the remainder of the journey.

As the *Niagara* continued paying out her load of cable, particularly from the lower deck, she began getting lighter and, therefore, rolling much more. Testing found a fault in the lower end of the cable and this section was cut out of the line. Communication with the *Agamemnon* continued without interruption. Icebergs were passed as the *Niagara* approached Trinity Harbor, Newfoundland. She was met by the British streamer *Porcupine* to pilot her to her anchorage near the telegraph house. At 1:45 in the morning of Thursday, August 5th, the *Niagara* anchored. She had laid down 1,016 miles of cable. Field immediately went ashore, woke the watch in the telegraph house and ordered them to prepare to land the cable. In exactly an hour after dropping anchor, a signal was flashed to the *Agamemnon* from the western destination of the line.

With equal dispatch a telegraphic message was addressed to the Associated Press in New York announcing the successful fixing of the cable to its western terminus. At noon, a 21-gun salute from the *Gorgon* made the event official.

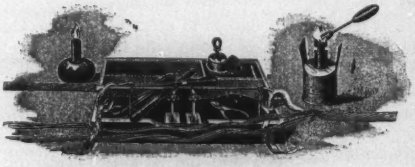
During the first day of her eastward journey, the engineers on board the *Agamemnon* made every effort to keep the rate of motion of the cable from the hold through the paying machinery at an even pace. The controls were set so that the strain on the cable would never get beyond the 1,700 pounds indicated on the dynamometer, which would be less than a quarter of the estimated cable-breaking strength. However, in the evening, an injured portion of the cable was discovered at a length of about a mile or two from the portion of the cable being paid out. Knowing that any effort to stop the ship or brake the cable might be disastrous, every effort was made to cut out the injured section and resplice the cable without stopping its rate of issue of about 6 knots per hour. Canning, the engineer in charge, realized that he had only about 20 minutes to complete the splice. But just before the lapping had been completed, Thomson reported a break in the circuit although the insulation had continued perfect. The new joint was therefore tested but, to everyone's alarm, the tests showed that the break was in a section already overboard, probably at a point some 50 miles from the ship. With this valuable time lost, it become imperative to stop the ship and risk mechanical breakage until the new splice had been properly completed.

Nearly all of the officers of the ship stood in groups about the coil watching Canning, who had supervised the original construction of the cable, direct the completion of the joint. But the rate of paying out was faster than the speed of completing the splice so that the order was given that the cable motion be altogether stopped while the ship rose and fell with the motion of the waters. The dynamometer indicated a stain on the cable of over 2 tons; this was critical and could not be maintained for any length of time. The joint was completed and the signal for the discharge of the cable was given. The cable issue was resumed with everyone relieved of the built-up tension created by the disturbing events.

However, the relaxation was only temporary because tests again indicated that the circuit was not complete. It was therefore decided to slow down on the emission of cable until the circuit was fully restored. A few minutes passed and the last hope was lost when the galvanometer indicated that the insulation had also failed. This meant that the cable had broken, probably near the *Niagara*.

Three minutes went by when suddenly the instrument became reactivated and contact with the *Niagara* was re-established. These disturbing results, having come so close to the start, showed that many uncertainties were still to be expected. Normal operations were resumed when, at dawn, another damaged section of the cable was discovered. This, however, was located at a point that provided ample time for proper repairs to be made.

The next day was a normal one with the ship's speed at 5 knots and the cable moving out at about 6 knots. The angle formed by the cable was about 15 degrees and the dynamometer strain indicated a maximum of 1,600 to 1,700 pounds. A head-on wind developed so that the ship made very little headway. It brought on the fear that if this continued the coal reserve would be used up and the crew would have to be reduced to burning the wooden fittings—masts, spars, and even the decks—to be able to bring the ship to its destination, Valentia. There was a temporary shift in wind but as night came a gale picked up and the heavy seas threatened to tear the cable from the ship as its stern rose. Constant alertness by the technicians attending to the cable machine reduced this hazard. The storm continued and as the stern fell and rose, the operators released the brakes while the stern was at its low point in the trough so that when the stern rose, the cable payed out. There was little sleep that night for all awaited the dreaded sound of the gun, as this would have reported that the cable had broken. Stormy days followed each other and slowly the work continued, the slender wire drifting out from the ship's stern as it rose and fell in the heavy seas.



To splice even a simple cable required about half an hour of skilled work by a cable crew, and the equipment shown. The conductors were joined, served, and soldered. The gutta-percha insulation was then put on and the protective armor wires restored.

On the fourth day out, there was noted a weakening of the electrical impulses from the *Niagara* which continued for the better part of an hour. Thomson believed this to be a weakening of the insulation or a faulty connection on board the *Niagara*. He notified the *Niagara's* electrician to this effect, and when the voltage was stepped up by increasing the battery power, the signals improved to normal and were even better than before. As the cable moved down into the cold water, the lower temperature and the increased pressure seemed to improve the insulation characteristics of the gutta-percha so that some of the temporary faults and disturbances were gradually eliminated.

On Tuesday, the weather began to improve after nearly a week of storm, but the seas still ran high. As the ship approached the shallower area which separates the telegraphic plateau from the Irish coast, the sea became calmer and the strain on the cable lessened. That evening the soundings showed a depth of only 250 fathoms. This was a help in changing from the main cable below deck to that on the upper deck, and this hazardous operation was successful. The next day, Wednesday, August 1st, the day was calm and beautiful, with only 90 miles separating the telegraph station at Valentia from the ship at noon. Everything looked very hopeful. With the *Valorous* leading the way, the ships moved on so that by daylight of the following morning the welcome heights surrounding Valentia lay ahead. The population on shore soon was awakened by the booming guns of the ships and was ready to welcome the crew and cable.

Signals from the *Niagara* indicated that they also were preparing to land. A stiff wind delayed the progress but by the afternoon the cable end was safely brought ashore.

CELEBRATING THE CABLE SUCCESS

TWICE, EFFORTS TO STRETCH a telegraph line between the north Atlantic continents had been tried and twice the efforts failed. An expectant public that hungered for the advantages that a transatlantic cable promised, had both times grown skeptical following the disappointments. A little more than a month had gone by since the latest failure had been reported, so that general interest had completely disappeared. Therefore, the announcement of the cable success telegraphically communicated from Newfoundland early that August day took America completely by surprise.

The message was flashed to every part of the United States, and enthusiasm reached the state of excitement as though a war had just been won. New York went wild with rejoicing. A hundred guns were fired on Boston Common and the bells of the city continued their joyous peal for an hour. For weeks the national jubilation continued and the Atlantic Telegraph remained the most important subject of conversation.

The public hunger for quick overseas news had to wait because it was Field's determined policy first to test the performance of the cable thoroughly, then to permit the exchange of greetings from the Queen of Great Britain and the President of the United States. Eleven days went by before the Queen's message of congratulation was received by President Buchanan. It required 16½ hours to transmit the 98-word message. He replied to the Queen joining her in congratulations ". . . on the success of the great international enterprise accomplished by the science, skill, and indomitable energy of the two countries." The 149-word reply required more than 10 hours to transmit.

Letters from dignitaries in every walk of life flooded into New York. Prof. Joseph Henry, dean of American electricians and Secretary of the Smithsonian Institution, hailed the achievement as marking "an epoch in the advancement of our common humanity."

THE CABLE FAILS

ON THE VERY DAY that all this celebrating took place, some undetermined break in the cable ended its usefulness, for it became silent just as its glory was being celebrated at its highest pitch. A violent lightning storm occurred over Newfoundland at about that time, and this at first was believed to be the direct cause of the failure. More sober analysis laid the break at a point about 270 miles from Valentia, at the location of the range that separates the deep Atlantic from the plateau of the Irish coast. Nothing that could be done restored the transatlantic voice. The cable was dead! Heartbreaking discouragement spread almost as rapidly as the news of its success. All the dreams of its accomplishments—all the visions of the many good and useful purposes which it was to serve—all this was suddenly ended. The waters had swallowed years of labor and millions of capital.

From its simultaneous landing on both sides of the ocean on August 5th, 1858, the operation of the cable had continued until the first of September, one day short of 4 weeks. In this time, some 400 messages were recorded, most of them technical details sent between operators on the performance of the instruments. But the performance of the cable proved uneven and frequently went out of service for hours at a time due to storms, magnetic disturbances, and unknown causes.

Few newsworthy messages were therefore accumulated in this time, not enough to have made a public impression. In mid-August a collision of two steamships had occurred off Cape Race. After clearance, and with special permission of Mr. Field, the news of this collision was telegraphed to London on August 20th and represents the first news message to be flashed across this cable. Notably, a dispatch of news sent on August 27th covering England, France, Prussia, Russia, China, Egypt, and India was received in New York and published in the evening papers on the same day that it had been dispatched from England.

The probable cause of the breakdown may be summarized as follows: the *Niagara* carried a battery of 75 cells of the sawdust (Daniell) type; these consisted of zinc and copper plates, each about 14 inches square,

immersed in a solution of sulphuric acid and water. To this, sawdust was added to prevent the liquid from slopping over during the ship's tossing. Each cell developed 1.1 volts. Supplementing this source of battery current was the testing apparatus recommended and used by Whitehouse who strongly believed in the necessity of testing the cable with high potential currents. For this purpose he used a large induction coil, 5 feet long, energized by a series of up to 500 very large cells, resulting in a charging voltage of approximately 2,000 volts. It was believed by Charles Bright that it was these high-voltage tests which ultimately ruined the life of the cable, for as the voltage was stepped up the communication results became poorer. The use of Thomson's reflecting galvanometer, when used with ordinary Daniell cells, was restored and produced the best results. However, by that time, the harm had already been done, the insulation damaged, and the cable failed. David E. Hughes, an eminent inventor and electrician, as well as Charles Wheatstone, confirmed this opinion. Thomson, writing in 1860, stated, "... and the writer—with the knowledge derived from disastrous experience—has now little doubt but that, if such had been the arrangement from the beginning, if no induction-coils and no battery-power exceeding 20 Daniell cells had ever been applied to the cable since the landing of its ends, imperfect as it then was, it would be now in full work day and night, with no prospect or probability of failure." Whitehouse had hoped to operate his improvement of Morse's electromagnetic recording instruments by activating relays which demanded considerable line current, whereas the galvanometer of Thomson required very little energizing current. The company Board found him stubborn, unco-operative, and insubordinate and therewith discharged him.

The disservice done to the cable and the company through the machinations of Whitehouse is illustrated by his behavior at Valentia when the 1858 cable was laid. In order to "prove" the effectiveness of his clumsy recording receiver, he had inserted a Thomson galvanometer at the receiving terminus, and had a clerk read this instrument. The signals thus read were repeated on a key at his table, which then recorded the signals on a Morse embossing recorder nearby. The strips from this were sent by Whitehouse to the directors in London, who were led to believe that the signals had arrived directly from Trinity Bay. Unfortunately, in accordance with instructions, no galvanometer, but a recorder, was in use in Newfoundland, so that the Queen's message, which required 16½ hours to transmit, was repeated back from Newfoundland in only 67 minutes.

Examining other difficulties, post mortem, that caused the cable break, it was realized that the cable itself was far from perfect, and although made hastily, yet it met the acceptable standards and was made by the best cable fabricators in the world at that time. Its high specific gravity caused it to sink too rapidly and made it rigid in handling. In addition, the cable was a year old when immersed; it had been coiled out of doors, exposed to the sun which had melted the guttapercha in places. Further, it had been taken on board the ships the previous year, then had been taken ashore and coiled on the Plymouth docks, and again stored in 1858. This meant that the cable had been twisted and untwisted as many as 10 times. The violent gale of June 1858 had done the cable on the *Agamemnon* little good, requiring many portions to be cut out. Was it any wonder that the cable failed? Or should it be said, was it not a wonder that the cable had operated at all!

The shy, scholarly Dr. William Thomson (Lord Kelvin) was also the keenest electrician and physicist of the enterprise. He served aboard ship on all five expeditions and contributed that essential electric instrument, the marine galvanometer, to the cable's ultimate success.

THE FUTURE IS PLANNED

In the following year, 1859, a committee of the most prominent engineers and scientists in Great Britain was appointed by the Board of Trade to launch an exhaustive series of experiments to overcome the difficulties experienced in the two previous cable layings. The Government was represented by Capt. Douglas Galton of the Royal Engineers; science was represented by William Fairbairn, president of the British Association for the Advancement of Science; electrical science was represented by Charles Wheatstone, the celebrated electrician, and Latimer Clark and his elder brother Edwin, both eminent telegraph engineers; George Saward, the secretary, represented the Atlantic Telegraph Company and, finally, general engineering was represented by George P. Bidder and C. F. Varley, an eminent telegraph mechanician. This committee concerned itself with such problems as the optimum size and form of cables, the required strength and degree of flexibility, the order of electric current required for such long distances, the type of conductor insulation and protective coverings required for this service and,

finally, the expected rate of speed for sending messages over the line. Every mechanical and electrical phase of this intricate problem was carefully examined. After sessions covering 2 years, the following succinct summary was given out by the committee. This report was followed by the publication of the full testimony of all the experts invited to testify.

London, 13th July, 1863.

We, the undersigned, members of the Committee, who were appointed by the Board of Trade, in 1859, to investigate the question of submarine telegraphy, and whose investigation continued from that time to April, 1861, do hereby state, as the result of our deliberations, that a well-insulated cable, properly protected, of suitable specific gravity, made with care, and tested under water throughout its progress with the best known apparatus, and paid into the ocean with the most improved machinery, possesses every prospect of not only being successfully laid in the first instance, but may reasonably be relied upon to continue for many years in an efficient state for the transmission of signals.

Douglas Galton,	Cromwell F. Varley,
C. Wheatstone,	Latimer Clark,
Wm. Fairbairn,	Edwin Clark,
Geo. P. Bidder,	Geo. Saward.

The 5 years between the disruption of the working of the cable and the foregoing report by the committee of experts was time devoted to the reconstruction of the whole enterprise. Once the technicians had demonstrated the feasibility of a transatlantic connection for even as little as one month, they knew that they were on a sufficiently sound foundation to build a more enduring telegraph system. It was a hunt for the weaknesses of the past installations that was uppermost in their minds. One of the surprises in the series of experiments and tests was the determination that the voltage required from the battery to penetrate the 2,000-mile crossing and ground return was much less than presupposed. This radical reduction in voltage indicated a safer operating condition by reducing the chances of electrical penetration of the insulation.

In this period, also, progress in the technology of submarine telegraphy was extended. By 1862, the Gutta Percha Company had fabricated 44 successful submarine cables of a total length of 9,000 miles. Glass, Elliot & Co. had made 30 successful submarine cables from 1854 to 1862. Even though the crossing of the Red Sea had been a failure, another one across the Mediterranean extended 1,535 miles from Malta to Alexandria. Still another cable, 1,400 miles long, crossed the Persian Gulf, the final link in a telegraphic chain that connected England to India. Slowly the public confidence in the practicability of submarine telegraphy continued to grow. It was during these years that Cyrus Field worked to revitalize his company.

THE CABLE OF 1865

Guided by the supervision of the Scientific Committee, appointed by the Atlantic Telegraph Company to examine offers on its invited bids for a suitable cable connecting Newfoundland and Ireland, specifications were prepared to produce a cable as "nearly perfect as human skill could make it." This was to be fabricated by the Telegraph Construction & Maintenance Company which was the name of the new company formed when Glass, Elliot & Co. merged with the Gutta Percha Company. Their specifications included, "That the conductivity of the wire should be fixed at a high standard, certainly not less than eighty-five per cent; that the cable should be at least equal to the best ever made; that the core should be electrically perfect; that it should be tested under hydraulic pressure, and at the highest pressure attainable in the tanks at the company's works; that after this pressure, the core should be examined again, and before receiving its outer coverings, be required to pass the full electrical test under water; that careful and frequent mechanical tests be made upon the iron wire and hemp as to their strength; that special care be given to the joints, where different lengths of cable were spliced together; and that, when completed, the whole be tested under water for some length of time, at a temperature of seventy-five degrees." We can smile today at such "tight" specifications. The high temperature of the water test was intended to assure a factor of safety, since the insulation improved at lower temperatures, and that of the test was 40 degrees higher than that of the Atlantic.

The comparison between the cable to be laid in 1865 and that which spanned the Atlantic in 1858 shows a considerable difference. The conductor core was to be of a cross-sectional area of copper three times that of the old cable; both had seven strands, but the weight per mile had been increased from 107 pounds to 300 pounds. The conductor was fashioned into primary core by being set in Chatterton's Compound (gutta-percha softened by Stockholm tar) and thus made highly water-repellent. The core was covered with four layers of gutta-percha which were interlaid with four layers of Chatterton's Compound. The new insulation weighed 400 pounds to the mile, compared to the old 261 pounds consisting of three layers of gutta-percha, the entire insulation of the old cable. The conductor consisted of seven strands of no. 18 B.W.G. copper wires.

Equal attention was given to the outer protective coating that was to guard the inner insulation and conductor, for the disturbing series of breaks in the old cable was not readily forgotten. The outer protection was therefore designed to consist of 10 stout wires of no. 13 gauge soft steel, each wire being wound with a layer of manila yarn saturated by a preservative and the covering of the 10 wires wound spirally about the central core which had already been wrapped in a layer of hemp saturated by a preservative. The reason for protecting the outer sheath in hemp was to preserve the cable from rust in either air or water exposure, and to reduce its specific gravity when lowered into water. The resulting cable was 1.1 inches in diameter and weighed 3,575 pounds per mile in air and only 1,400 pounds in water. The shore ends of the cable had an additional

sheathing of 12 strands, each strand consisting of three heavy galvanized iron wires of no. 2 B.W.G. of total weight of 40,000 pounds per mile. Thirty miles of the shore-type cable connected the Irish coast with the deep-sea cable. Eight miles of the heaviest type stretched from the coast westward, then 8 miles of an intermediate type, and finally 14 miles of a still lighter type which was spliced to the ocean length. For the Newfoundland coast, the reverse arrangement was made, but was condensed into a span of only 5 miles.

The combination of elements was intended to provide the cable with the maximum combination of strength and flexibility, with lightness of weight and freedom from corrosion in the salt water of the ocean. The increased bulk and increased weight were more noticeable on land although the specific gravity of the cable was less than that of the old cable. Another advantage in the increased bulk was that when passed overboard, it sank more slowly and therefore could give a better angle of immersion, thereby exposing the cables to less strain as the stern of the ship rose and fell. Just such a maneuver had caused the breakage of the cable leaving the Niagara in 1857.

The tensile strength of the combined elements forming the cable was given the greatest attention. The tensile strength of the 1858 cable had been 6,500 pounds and this was raised to 15,500 pounds for the proposed cable. Looked at in another way, when immersed, the old cable could sustain less than five times its own weight per mile, which made it useless for depths exceeding 5 miles. The new specifications required that the cable support 11 times its weight per mile in water, thereby providing a factor of safety of 4 in the maximum sounded depth of 2½ miles along the cable route.

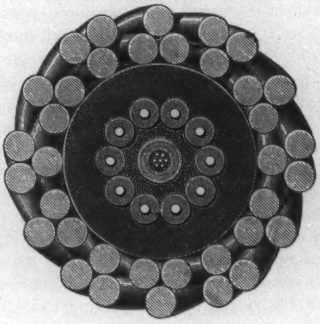
It was also decided to build the cable in one single length of 2,300 nautical miles (nearly 2,700 statute miles). But where was the ship that could store and handle such bulk and weight?

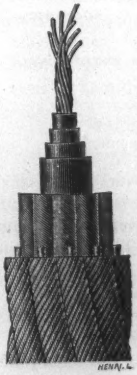
THE *GREAT EASTERN*

IT WAS ONLY A FEW YEARS EARLIER that England saw the construction of the *Great Eastern*, a ship of enormous proportions intended for transatlantic passenger service but her very size prevented her use in commercial traffic. For 10 years she had been waiting to be put to practical use; now her dimensions and seaworthiness indicated that she could be very suitable to carry and lay the Atlantic telegraph.

Big as the ship was, still an additional load of some 5,000 tons was something to be concerned about. To pile such a great mass in one coil would certainly injure the bottom cable layers. Further, a rolling ship would cause the load to shift dangerously. Someone computed that if the cable were to be coiled into one cylinder it would form a pile 58 feet in diameter and 60 feet high, enough to fill one of London's largest theaters from the floor to the roof. To make the storage of such a weight practical, it was decided to distribute the mass in three tanks, one placed forward, one amidships and one in the aft part of the ship. These three tanks were made of water-tight wrought iron plates, the forward one holding 633 miles of cable, the other two carrying 800 miles each; they were filled with 2,000 tons of water to keep the cables immersed until sent out into the ocean.

The electrical department was placed in charge of Mr. de Sauty, who had also acquired considerable experience in submarine telegraphy between the Atlantic trials. Responsible to him were Professor Thomson and





The improved cable used in the 1865 and 1866 expeditions. The two illustrations at left and below show the main ocean section; the heavy shore-end section is shown above. The seven-strand copper core was covered by 4 layers of gutta-percha, wrapped in tarred hemp and protected by 10 steel wires, each wrapped in impregnated hemp.

Mr. Varley, whose duty it was to see that the high-performance standards built into the cable in the production plant were maintained during the laying operations. As was reported later, "The result of their repeated tests was to demonstrate that the cable was many times more perfect than the contract required. With such marvellous delicacy did they test the current of electricity sent through it, that it was determined that of one thousand parts, over nine hundred and ninety-nine came out at the other end!" Of the 500 men aboard the *Great Eastern* when she sailed on July 15, 1865, there was only one American—Cyrus Field.

(The third and concluding installment will appear in the November issue.)

Supervisory Control for Missile Test Center

C. L. CADWELL
MEMBER AIEE

WHEN a guided missile is launched from Cape Canaveral, Fla., it is first tracked and controlled by the radar and radio equipment at Cape Canaveral. As the missile progresses down range, the tracking and control is transferred from station to station as the missile passes out of the range of one station's radar and radio equipment into the range of the next station's radar and radio equipment. Likewise, the reception of telemetering data from the missile is transferred from station to station as the missile progresses down range.

The "supervisory control" equipment provides remote control of radio transmitters, radar equipment, and telemetering receivers at the down-range stations from Cape Canaveral. This enables control signals to be sent from Cape Canaveral over submarine cable to a selected station and then fed into radio transmitters for transmission to the missile. Also, the telemetering data can be received at a selected station and sent to Cape Canaveral over submarine cable. Formerly, pilots and range safety officers at various down-range stations were required, with the control passing from one pilot to another and range safety monitoring from one officer to another.

The supervisory control consists essentially of two parts:

1. Station control equipment.
2. Missile control channelizing equipment.

The station control equipment provides for on–off control of radar gear, radio transmitters, communication equipment, and telemetering receivers at down-range stations, and monitors their status. The missile control channelizing equipment transmits signals from the pilot at the Cape over the submarine cable carrier system through the selected transmitter at the selected station to the missile guidance and control.

To control the down-range stations, two binary multistation relay control sets are used, operating over frequency-shift tone channels. The code consists of long and short pulses with an additional check pulse for single error checking. Additional checking is accomplished by sending a report code from the selected station back to reset coders and decoders at the Cape and other down-range stations. This report code also turns off functions at the outgoing station upon selection of the same function at the incoming station. Control operations are initiated by pushbuttons on master control panels located in the control building at Cape Canaveral.

Digest of paper 58-1296, "Supervisory Control for Air Force Missile Test Center," recommended by the AIEE Substations Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Power Apparatus and Systems*, Feb. 1959.

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The down-range stations are monitored by modified binary scanning relay indication sets which operate indicating lamps on the master control panels. Each set makes a complete scan when a change of indication takes place. Each pulse represents a function being supervised. If the pulse is long, a green lamp indication is received denoting that the equipment supervised is on. If the pulse is short, a red lamp indication is received denoting that the equipment supervised is off.

The supervisory control equipment also provides the adjacent down-range stations indications of certain functions in any particular station. For example, stations three and five have indications of certain equipment status as station four. Likewise, stations four and six have indications of certain functions at station five and so on. This information is provided by the binary multistation control sets.

The supervisory control operates over frequency-shift type tone channels. Three tone channels are used for the control system. One channel is used for each station for the indication sets. Each tone transmitter and each tone receiver has a standby, which is automatically individually placed into service by monitor circuits in case of failure of the normal unit. In addition, each channel is monitored by the supervisory indication sets so that the operator at Cape Canaveral knows the status of all supervisory tone channels at all times.

The missile control channelizing equipment sends control signals from the missile control equipment at Cape Canaveral over the submarine cable through the selected transmitter at a selected station, to the missile for missile guidance and control. The channelizing equipment consists of frequency-shift tone channels which have 100% standby units for greater reliability. Again, monitor circuits are used which will automatically switch from normal to standby in case of failure. The channelizing equipment consists of two types, either of which is used depending upon the type of missile being tested. One type consists of 17 channels, providing 17 on–off controls. The other type uses 11 of the 17 channels as on–off control plus two 360° shaft position telemetering functions.

The application of supervisory control has enabled a single pilot at Cape Canaveral to control the missile throughout its entire flight. Likewise, the range safety officer at Cape Canaveral can maintain instantaneous safety control throughout the entire flight. Telemetering data may be transmitted up range on the submarine cable and collected at the control station, and the decisions on switching and controlling may be made by the same personnel throughout the flight. This results in more uniform operation and more uniform results in the collected data.

Space Electric Power Transmission

G. W. BILLS
ASSOCIATE MEMBER AIEE

To provide shielding for crews of manned space vehicles utilizing nuclear sources, considerable distance between the power source and vehicle may be necessary. Some of the problems involved in the design of the required transmission line are discussed.

THE ERA of manned space ships has almost begun, but to date no practical auxiliary electric power units for them are available. At present, the only energy sources capable of supplying power in adequate amounts and for long durations are nuclear reactors, radioactive isotopes, and solar energy converters.

For manned space vehicles whose power requirements exceed 10 kw, solar energy converters do not seem adequate as compared to nuclear or radioactive sources. The latter two sources appear to be the most practical for power units, although to obtain enough isotopes for power greater than 100 kw might be a prohibitive problem, both in cost and procurement. For either source, shielding must be provided for the crews of the space vehicles. To provide such shielding without the addition of exorbitant weight, the distance between the power source and the manned vehicle must be exploited to obtain the advantage of the inverse square law for radiation, unless new shielding techniques are discovered. In the case of isotopes whose radiation cannot be controlled, the launching period would not permit distance shielding. For this reason, nuclear reactors appear to be the only practical power source, since distance shielding is possible and their radiation can be controlled. Distance shielding will require an electric power transmission line between the power source and the manned portion of the missile once the missile has been propelled into its initial orbit.

In the early phases of space travel, it seems certain that there will be space stations in orbit which will act as centers for assembling lunar and planetary exploration spacecraft. One possibility is a nuclear-powered electric power station from which transmission lines will extend out to numerous service stations necessary for the various activities involved in interplanetary flight preparations. Also, for bases on the moon and other planets, it may be necessary to have central nuclear reactor power stations from which power would be available over power lines.

In all cases, the weight of transmission lines and energy sources must be minimized to conserve propulsive effort needed for lifting them into orbit. Therefore, it is obvious that space electric power transmission line design must be based on weight conservation principles rather than on the conventional cost basis familiar to all transmission line engineers.

Electric power transmission in space will obviously be different from that on earth where there is an atmosphere and a gravitational field. Spacecraft in outer space orbits have an environment such that vacuum can act as an insulator, and conductor mass has negligible effect except during acceleration; both of these factors should aid in optimizing the power transmission solution. For altitudes over 100 miles, it is believed that there will be little or no corona and flashover, and spacecraft should actually operate so that perigee is always above 100 miles.

The subject of this article could have covered two parts: (1) power transmission exploiting conventional techniques such as power cables, and (2) power transmission by more exotic methods such as electromagnetic radiation and possibly the beaming of particles. However, to date there does not appear to be any practical and efficient method to transmit as much as 10 kw between two points in space other than with metallic conductors. As a consequence, only the former method shall be considered.

SPACE TRANSMISSION LINE FACTORS

BECAUSE the shielding distance between a missile and its nuclear power plant depends on such parameters as the size of the reactor, type of shielding, and many other considerations, the problem of determining a minimum-weight space power system is, in general, extremely difficult. However, if only the line itself is considered, it is possible to formulate certain conclusions.

Considering only the line, the important transmission line characteristics to be determined are listed as follows:

1. Type of system, i.e., a-c or d-c
2. Conductor material
3. Configuration (i.e., two or three conductors)
4. Weight
5. Cross section

These, of course, depend upon the magnitude of power transmitted, types of loads, and many other variables. However, some of the characteristics can be determined from general considerations.

Although electric power transmission on earth is predominantly a-c, in space it probably will be d-c. To begin with, the direct conversion of nuclear reactor heat

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to electricity by thermionic[1] or thermoelectric[2] techniques is more reliable, should require less weight, and introduces no undesirable torquing effects; it will be d-c in nature, although a-c is possible. As has been pointed out for high-voltage[3] conventional transmission lines, d-c is more economical than a-c, provided practical converters and inverters can be supplied at both ends. Unfortunately, d-c to a-c inverters for large currents and high voltages have not been available, and rectification at the generating end is also an additional expense. Mainly for these reasons, d-c transmission on earth has not been exploited.

High-speed, reliable switching devices[4] are now in existence which can convert d-c to a-c and transform d-c voltages up or down. As the need for these devices becomes greater, larger and better ones will be produced. Also, many missile loads require d-c. In addition, when a-c is necessary, more than one frequency is often desirable, necessitating frequency changers if a-c transmission is used.

Another factor favoring d-c transmission is the possibility of radiation losses with high-frequency a-c transmission. In most missiles, 400-cycle frequencies are common and studies have indicated that 2,400 and 3,000 cycles are desirable. Electromagnetic radiation losses may be appreciable at the latter frequencies and must be considered. With d-c transmission, there are no difficulties that might arise due to system instability or excessive steady-state voltage drop because of inductive effect. Also, d-c conductors have no skin-effect losses and the current density is more uniform than for a-c. For these reasons, it shall be assumed that d-c transmission is better for space.

The two modes of operation of conventional d-c systems are constant current or constant voltage. Constant-current operation is much too inefficient and requires special equipment such as a monocyclic square; therefore, as in a-c systems, a constant voltage principle will be assumed. Voltage regulation at the receiving end may be controlled either by d-c regulators at the receiving end or by remote control of the sending-end voltage.

It appears from a survey of possible conductors that the conductor material will have to be aluminum or copper. For the same ohmic resistance and operating temperatures, an aluminum cable would weigh about 49.7% as much as a copper cable. Since there is little strength requirement for a space transmission line, there is no justification for using copper or even aluminum steel-reinforced conductor, unless copper can be operated at a temperature high enough above that at which aluminum could be operated so that the weights would be comparable.

A simple 2-wire configuration appears to offer the minimum-weight solution. For two separate conductors, the repulsive force between the conductors, because of equal and opposite currents, would tend to keep the wires apart. In fact, this force might be large enough to draw the two parts of the craft toward each other as the conductors were forced apart. A 2-line transmission line would require attitude control of the missile components parts to prevent the wires from being twisted together because of rotation of the parts with respect to each other.

Weight and size of conductors will be determined primarily by the allowable voltage drop, the ohmic losses, and the allowable temperature of the metal. The three factors are closely related. For example, the voltage drop is equal to the power loss if both are expressed in per cent. Also, since the resistance is dependent on conductor temperature, and the voltage drop and power loss are proportional to resistance, it is obvious that changing any one of them will change the other two. The problem of obtaining a minimum-weight electric system is quite involved if both the energy-source and transmission-line weights are considered. If an initial assumption is made, solely for convenience, that approximately a constant-weight nuclear reactor is required, regardless of the size of the electric load, we can make a preliminary investigation of the minimum conductor weight per centimeter of length per kilowatt of transmitted power.

One solution is to assume that the wire will operate at its highest possible temperature, this temperature to be determined by its melting point and mechanical strength characteristics. The resistance can then be determined by a consideration of the I^2R losses and the resultant temperature equilibrium which would depend on the resistance of the line (since the receiving power, voltage, and current are assumed constant for the maximum load conditions) and the radiation of heat from the conductor.

As shown in the Appendix, it is possible to calculate the weight per unit length of a conductor once the operating temperature, current flow, and ratio of length to width of the conductor cross section are assumed. Obviously, to carry the maximum amperes per pound of conductor it is necessary to operate at the highest possible temperature. However, by choosing a ribbon or rectangular cross section so as to obtain a feasible conductor with the largest surface for radiation, the conductor can carry more current for the same operating temperature because heat radiation would be greater than for a conventional cylindrical conductor. It should be remembered that in space, with its near vacuum, all heat losses must be dissipated by raising conductor temperatures and by radiation into space. On earth, heat conduction and convection are appreciable factors which aid conductors in dissipation of heat losses, but these are not available for space electric power transmission lines.

SPECIFIC EXAMPLE

Consider a space transmission line which has to conduct 1,000 amperes. Disregarding everything but the line itself, curves of grams per centimeter vs absolute temperature can be calculated for copper and aluminum conductors for the assumptions given in the Appendix. These curves are shown in Fig. 1. It is immediately apparent, recalling that the melting temperature of aluminum is 1,220.4 F and that of copper is 1,981.4 F,

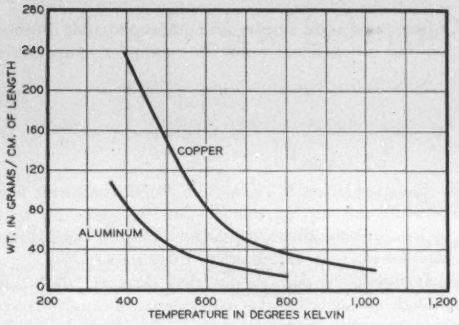

Fig. 1. Curves of weight vs temperature for 1,000-ampere conductors.

that a copper conductor could be used to carry 1,000 amperes at 1,000 K (1,340 F) which would weigh no more than an aluminum conductor operating at 700 K (800 F). Unfortunately, the resistance drop per centimeter is approximately three times greater for the copper than for the aluminum. For most practical cases, this would require a larger energy source for the copper-conductor system.

Assuming that a 2-conductor system 1,000 feet in length is to be used, from the curve in Fig. 1, a weight of 20 grams per centimeter of length would be required for an operating temperature of 700 K (800 F). Total weight of the conductor would be 2,690 pounds—a far from negligible amount. This weight might have to be increased if insulation spacers are used or if the conductor surface is anodized to increase emissivity and insulation resistance.

Thus, it can be seen from this simple example that space electric power transmission line weight is going to be quite a factor in space travel. However, when it is recalled that nuclear reactor shielding weights as high as 100 tons have been mentioned, partial shielding by means of distance may be quite feasible weightwise even though metallic conductors are required for power transmission.

GENERAL CONSIDERATIONS

FOR PRECISE DESIGN of space transmission lines, considerable investigation and computation will be required. Heat radiation equations for conductors will have to be determined, possibly from tests to evaluate empirical constants, since very little has been published on this subject. This experimentation would have to include effects of anodized surfaces, the latter also requiring experimental effort to arrive at the optimum anodizing procedures.

Actual minimization of a nuclear reactor powered space electric system is going to require considerable effort because of the many variables involved and because of the inherent nonlinearity of the problem. Since only cut-and-try procedures are possible for such an optimization problem, the most economic solution will be accomplished with the aid of a digital computer from a digital program which would include such variables as conductor temperatures, resistivities, nuclear reactor weights, shielding weights, and conductor lengths.

CONCLUSIONS

SPACE ELECTRIC POWER TRANSMISSION LINES will be made of aluminum with a rectangular or ribbon cross section. They may be anodized to obtain an insulation layer and to increase their emissivity. Operating temperatures will have to be much higher than for conventional lines on earth so as to minimize weight.

D-c operation of the lines appears to be desirable, especially so when thermoelectric generators for converting nuclear energy to d-c electricity become available.

The actual design of a space vehicle secondary power system will require the solution of a complex problem to determine the power plant size, conductor cross-sectional area, and operating temperature that will weight-minimize the entire system.

Appendix

Determination of conductor size and weight for space transmission lines is possible by solving the relation which equates I^2R losses in the conductor to the radiated heat of the conductor.

Assuming that the operating temperature of the conductor has been determined by test and experience and that the load current is given, it is then possible to solve for the conductor area. Once this is known, the conductor weight may then be calculated.

Published material on heat radiation of conductors is almost nonexistent. It appears that considerable experimental research will be required to develop accurate heat radiation formulas for conductors of current. However, for the purpose of this article, the equation given by Jakob[5] should be adequate for the following analysis.

The radiated heat in ergs per second per square centimeter for a conductor is

$$N = 1.084\ (10^9)\ C_1 \sqrt{r_c} \left(\frac{T}{100}\right)^5 \qquad (1)$$

where C_1 is the first constant of Planck's law, r is the resistivity of the metal at 0 degrees C, and T is the temperature in absolute degrees Kelvin.

Equation 1 may be altered to give the heat (denoted by H) radiated in ergs per second per centimeter of conductor length, and then has the following form:

$$H = 2 \times 10^4\ S \sqrt{r_c} \left(\frac{T}{100}\right)^5 \qquad (2)$$

where S is the radiating surface of the conductor in square centimeters.

The I^2R loss in ergs per second per centimeter length of conductor is:

$$I^2R = (10^7)\, I^2 \frac{r}{A} \tag{3}$$

where I is in amperes, r is resistivity in 10^{-8} ohm-centimeters of the conductor at temperature T, and A is the cross-sectional area of conductor in square centimeters.

To obtain a conductor with a large radiating surface, assume that the cross section of the conductor has a width 10 times greater than its depth. (It should be realized that an optimum conductor cross section will be determined only after careful theoretical and experimental investigation, but here such a procedure is not necessary.) If d is the depth and w the width, both in centimeters, then for 1 centimeter of conductor length,

$$S = 2\,(d + w) = 22d \tag{4}$$

and

$$A = wd = 10d^2 \tag{5}$$

Substituting equations 4 and 5 into equation 3 and solving for d:

$$d = \left[\frac{2.27\, I^2 r}{\sqrt{r_e}\left(\frac{T}{100}\right)^5}\right]^{\frac{1}{3}} \tag{6}$$

The conductor weight per centimeter length may then be calculated from equation 7

$$w = 10d^2 \text{ (specific density)} \tag{7}$$

where the specific density is in grams per cubic centimeter and is dependent upon the conductor temperature.

Substituting equation 6 into equation 7,

$$W = 10\left[\frac{2.27\, I^2 r}{\sqrt{r_e}\left(\frac{T}{100}\right)^5}\right]^{\frac{2}{3}} \text{ (specific density)} \tag{8}$$

Using equation 8, a curve for weight conductor temperature can be determined. This was done for both copper and aluminum conductors, in both cases assuming that $10d = w$ and that $I = 1{,}000$ amperes.

It should be pointed out that these equations, although adequate for this article, are only indicative of an approach to be taken in the design of space electric power transmission lines.

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Ultrasonic Gauging of Missile Nose Cones

Hundreds of nose cones for the Nike-Hercules missile are here awaiting inspection by means of an ultrasonic resonance gauge. Shaped on hydroforming and hydrospinning machinery at the Lycoming Division of the Avco Corporation, Stratford, Conn., these nose cones must be extremely accurate both in contour and in size.

The Vidigage (registered trade mark, Branson Instruments, Inc.) is used because of its reliability and ease of handling. This ultrasonic gauge provides thickness readings instantaneously, and to extremely close tolerances.

After only a few hours of training, Lycoming inspectors operate the gauge with complete confidence. When the transducer is placed against only one (the outside) surface of the cone, the high-frequency mechanical vibrations are transmitted to the metal. Fed back into an electronic circuit, resonant vibrations are shown by two or more vertical traces appearing on the face of the cathode-ray tube. A scale which is placed in front of the tube indicates the wall thickness directly.

A New Isolated-Phase Bus Design

H. H. RUGG
MEMBER AIEE

P. H. WESTERMEYER
MEMBER AIEE

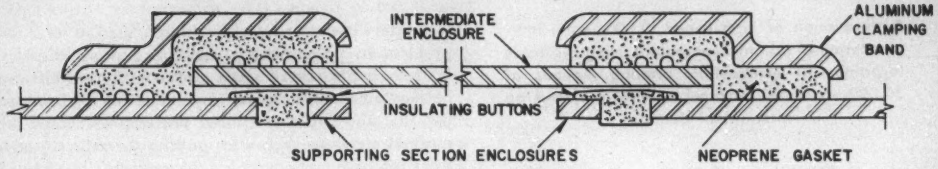

Fig. 1. Section of gasketed joints.

THE ISOLATED-PHASE BUS which is described here has been developed to meet the need of the modern generating station for a design which is simple to install, has tight enclosure joints, adequate mechanical support and insulation, and easy accessibility when required.

The two important points in which this bus differs from previous designs are, first, the gasket arrangement has been improved and simplified and, second, only one insulator is used to support the bus conductor at each support station.

The number and length of gasketed joints has been reduced by eliminating longitudinal housing joints. The circumferential gasket is a neoprene band and is clamped directly against the enclosures by a single aluminum ring which is formed in two halves with simple clamping fittings (Fig. 1). The contact of the gasket with the housing is visible at all times. Its assembly can easily be made, even by unskilled workmen.

The same housing arrangement can be used for the all-welded enclosure which is being installed by some bus users. The gasket and clamping ring are omitted and a narrow aluminum filler strip is inserted in the space between the housings. A weld can then be laid on to form a permanent seal. Inasmuch as no modification of the housing ends is required, this bus can be installed with gasketed joints and, if desired at a later date, the gaskets can be removed and the joints can be welded in the field.

The special design of the single insulator and its supporting details makes it entirely adequate to meet the mechanical forces on the conductor inside the relatively high conductivity aluminum enclosure. This conductor support is bolted directly to the supporting feet which project through the enclosure. They are welded to the housing by an easily accessible continuous weld, all on the outside (Fig. 2). There are no other openings through the housing wall except those fitted with filter drains.

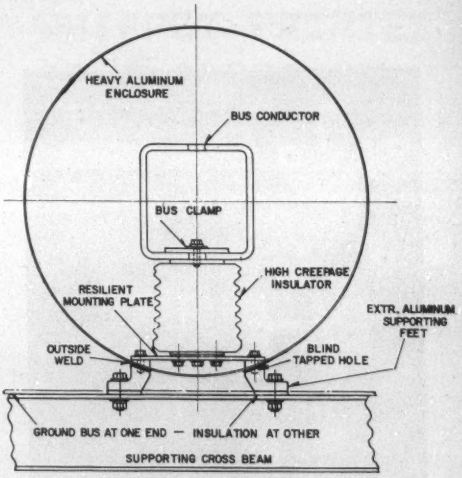

Fig. 2. Section through conductor and housing.

The main conductor and housing sizes have been worked out on the basis of aluminum as the standard conductor material. The conductors up to the 8,000-ampere rating are formed from two channels in a hollow square. The larger sizes are cylindrical in shape. By taking advantage of the variable strength and conductivity characteristics of the available conductor alloys, a series of economical conductor sections was developed for the standard 500-ampere steps which increase one inch in size for each successive rating.

Aluminum conductors and their connecting details, both solid and flexible, can be bolted or welded, or a combination of the two methods can be used. If desired, all joints in the factory assemblies can be welded and the field joints connecting these assemblies can be either bolted or welded.

Digest of paper 58-1313, recommended by the AIEE Switchgear Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Power Apparatus and Systems*, Feb, 1959.

H. H. Rugg is with the Westinghouse Electric Corp., East Pittsburgh, Pa.; P. H. Westermeyer is with the Westinghouse Electric Corporation, Cincinnati, Ohio.

High-Speed Terminal Printers

K. M. KIEL

A description of high-speed (3,000 wpm) low-cost terminal printing equipment using the basic technique of electrostatic printing. Speeds of 30,000 wpm are practicable with line feed on intermittent demand.

THE NEED for high-speed, reliable, low-cost, terminal printers in communications and data processing has been forcefully brought home with the advent of electronic computers, telemetry, and electronic data-processing systems. Our ability to print-out has not kept pace with our ability to furnish information at high speeds. Electromechanical devices are being pushed beyond their practical ultimate limit, resulting in unreliable, high-cost operation.

Fig. 1. A 3,000-word message typed by an engineering development model of a sending–receiving teleprinter.

In studying this problem, Burroughs engineers considered many other approaches: chemical, electrochemical, optical, magnetic, and many other processes. It was finally concluded that, in order to get a visible change at the desired speeds, mass of some kind would have to be moved, and the mass would have to be extremely light. The obvious answer—the electron. Hence, the answer to the problem of high-speed paper tape recording is the same electrostatic technique used to solve the problem in page printers, oscillographs, or displays. With a simple row of seven electrodes, seven dots can be deposited on the paper tape in a microsecond—so fast that the paper tape need not stop to accept the spray of electrons. Yet, after pulling the tape through a dry ink bath and over a hot fixing roller, the charged spots stand out in clear, readable dots without smudge.

An engineering development model of a sending–receiving teleprinter is shown in Fig. 1. The machine is based on this technique and was developed for the U.S. Army Signal Corps at Fort Monmouth, N.J. Delivery was made recently, and it is presently being put through its paces by the U.S. Signal Corps Laboratories.

This machine is about 15 cubic feet in volume. The upper right-hand section is the mechanical portion of the teleprinter, housing a 1,000-foot roll of paper 8½ inches wide. The print heads, inker, and fixer are also contained in this portion. The cabinets below and to the left house the electronic elements including the power supply.

Fig. 2 illustrates the basic technique of electrostatic printing. This shows the simple three-step process that converts electric impulses into the printed word.

RECORDING MEDIUM

THE RECORDING MEDIUM is the final hard copy on which the printing takes place. The medium is a special but low-cost paper coated with a very thin layer of any one of many high-resistivity coatings such as polyethylene. The paper is pulled over a conducting rear electrode with the coating side away from this rear electrode. A recording pin, which can be a simple round conductor, is spaced approximately 0.005 inch away from the surface of the paper opposite the rear electrode. An electrical potential of about 1,000 volts is applied between the pin and the rear electrode behind the paper, causing the air between to ionize. This permits electrons to flow from the negatively charged pin toward the rear electrode. Many of the electrons are trapped on the surface of the highly resistive coating and an electrostatic latent image results.

The paper is then pulled through a bath of dry, noncharged ink which adheres only to the charged areas on the paper. The agitator merely shakes off the excess ink from the background. The paper continues over

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The author wishes to acknowledge the valuable technical assistance given by R. E. Benn, manager, Digital Communications Department, and G. A. Harris, project engineer, Burroughs Research Center, Paoli, Pa.

a temperature controlled platen or hot plate—about 400 F—which softens the coating on the paper, and the ink is pressed into the coating by means of the pressure roll. The result—an immediately readable, dry, permanent, hard copy.

The electrostatic printing technique put to work is shown in Fig. 3. A blow up is shown of alpha-numeric characters, each formed by a 5×7 matrix of dots. These dots are formed from the electrons which flow from the ends of the round recording pins such as the one just mentioned. Of course, other symbols can easily be formed by a different selection of pins to be pulsed.

Fig. 4 is a diagram of the print head for the page printer. Here, many print heads—each containing a matrix of 35 wires—five wide and seven high—are lined up across the page. Then each print head can print any desired character or symbol, without movement, through selection of the correct recording pins. The space between dots is filled in by increasing the intensity of the charge and creating an image actually larger than the recording pin. Each print head is locked into position and remains in a fixed position since no movement of the print heads is required—no slap-bang of hammers or type bars.

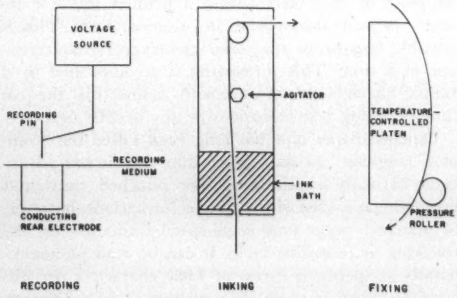


Fig. 2. Diagram illustrates basic technique of electrographic printing. This shows the simple three-step process that converts electric impulses into the printed word.

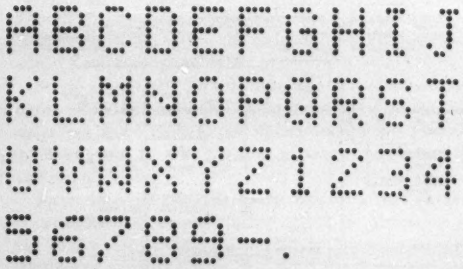


Fig. 3. Blowup of alpha-numeric characters each formed by a 5×7 matrix of dots.

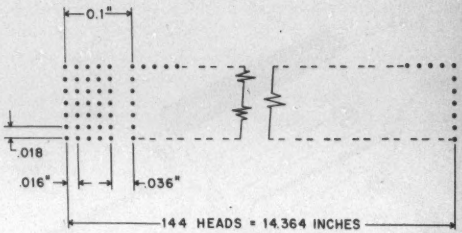


Fig. 4. Diagram of a print head for the page printer.

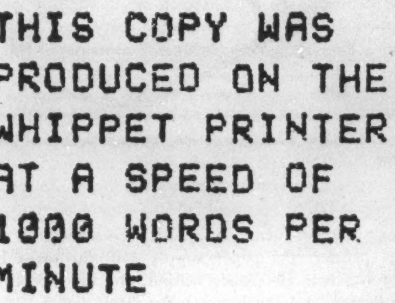


Fig. 5. Actual reproduction of printing done by the Whippet page printer.

Fig. 5 is an actual reproduction of the printing done by the Whippet page printer. This is the electrostatic page printer developed and built by the Burroughs Corporation for the U. S. Air Force's Cambridge Research Center. It was a feasibility model. The printer is currently under a redesign phase and several engineering test models are being built for the Air Force for use in their *433L* Weather Observing and Forecasting System. This feasibility model proved its practicability, and of course the next models will have the full 72-character line.

HIGH-SPEED CAPABILITY

Because the static charge can be deposited in less than one millionth of a second, the machine has inherent high-speed capabilities resulting in low-cost simple circuits within the machine. The 72 print heads are all connected in parallel; that is, a character that is set up on one head is set up on all 72 heads simultaneously. By a coincident voltage technique, the rear electrode is pulsed only in the desired column, thereby printing only in the desired column. The machine simply sits and waits for the next character to be received, and when it is, it decodes the input signals and encodes the character by proper selection of the 35 pins. The rear electrode is pulsed in the desired column and the process repeated for the next character.

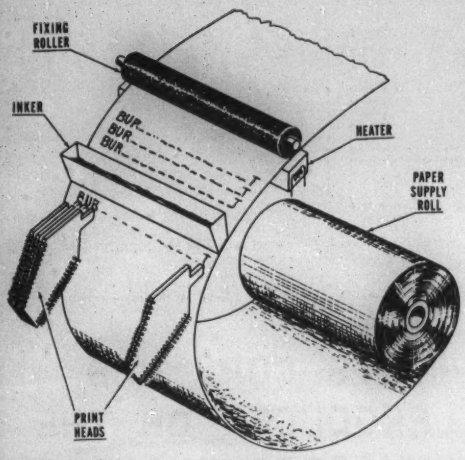


Fig. 6. Burroughs electrostatic printing technique as used in the page printer.

Fig. 6 makes it easy to visualize the schematics of the page printer: the paper supply roll, the print heads with the rear electrodes behind, the dry ink trough, the heater, and the fixing roller. It is worthy of note that no photoconductive surfaces are necessary—no charged ink to become contaminated and no necessity to deposit the ink on one surface before transferring it to another. The charge and the ink go directly onto the final hard copy, eliminating the really costly and time-consuming operations.

Speeds up to 3,000 words per minute (wpm) are standard on both page printers. Speeds of 30,000 wpm are not only possible but also are practicable with line feed on intermittent demand. Beyond 30,000 wpm with a 72-character-wide line, continuous paper movement appears to be more practicable. However, when we get away from intermittent demand paper feed, the buffering and formatting can become costly. Notice that there was no buffering or storing of a single character on the page printers described. The characters are printed as fast as they are received, one character at a time, across the page.

The logic diagram for the Burroughs Electrostatic Page Printer, Whippet, in Fig. 7 is interesting. In the upper left, a six-bit code, generally supplied by an input tape, is received in parallel. If serial bits are received as in standard teletype transmission, a receiving distributor naturally would be the first block on the diagram. Subsequent models will include the solid-state receiving distributor, getting away from inherent weaknesses of electromechanical stepping switches and the like. In fact, the whole machine will be solid state to attain unprecedented reliability in printers. The only mechanical movements are in the paper space-up and inking mechanisms.

Cathode followers drive a conventional diode matrix which decodes the six-bit code. The next diode matrix is the character encoder. This selects the correct print pins to be pulsed. There is one print pulse generator for each pin in the print head and, since all print heads are connected in parallel, only 35 pulsers are needed here. The functions of the printer are synchronized by use of the sprocket-hole channel in the tape. This signal triggers the printing pulsers. The rear electrode pulse is applied first and longer to permit circuit capacitances to die out. As previously stated, since a character to be printed is set up on all heads simultaneously, the column in which the rear electrode is energized is the column in which the printing will occur.

Paper advance and carriage return signals are the same as in standard teletype code. Of course, since the print heads do not move, the stepper switch, or as in the latest solid-state model, an electronic switch, returns the printing from the last column to the first column.

Line advance is accomplished in less than 20 milliseconds. This is at the rate of more than 50 discrete, intermittent space-ups per second. An electromechanical clutch and brake arrangement is used.

Wide-line printers of 144 or 150 columns for computer readout are sure to evolve. There is practically no limit to the printing speed. It boils down to "how fast can the paper be moved?" It is easy to rearrange the sequence of characters within a printed line—for instance to print information in columnar form. This is possible because of the serial printing of characters—one at a time. This formatting is accomplished by a simple patch-board arrangement connecting the column-selecting rear electrodes in any desired order.

Punched paper tape has long been called the "common language" in data processing, and it has advantages in many applications over punched cards and magnetic tape. One of the serious limitations, however, of punched paper tape is its speed limitation on the receiving or recording cycle. It can be read photoelectrically at speeds in excess of 1,000 characters per second, but when it comes to punching, it is a different matter. Much development money has gone into high-speed punches but efforts to go beyond 75 or 100 char-

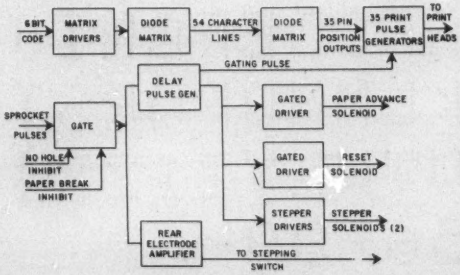


Fig. 7. Logic diagram for the Burroughs electrostatic page printer, Whippet.

acters per second seem to be pushing a good thing too far. Visualize stopping the paper, indexing the correct punches, moving the mass of the punch through the paper, removing the slug, withdrawing the punch, and finally moving the paper tape to a new position—all these operations—75 times per second!

By substituting printed black dots on a paper tape with the electrostatic technique, recording and reading can be done at a lazy pace of 1,000 characters per second, or 10,000 words per minute. If edge interpretation of the code is desired, it can simultaneously be printed in readable English language at the same speed. Hardware to prove its reliability at 3,000 words per minute was developed for the Air Force where results of the final test showed that out of 24 million bits recorded and read, only one character error occurred. This represented 3 million characters—with only one error. Packing densities of the coded characters were the same as punched paper tape which meant 10 characters per lineal inch. This can be improved, but there is some advantage to having a general-purpose tape reader capable of reading either punched tape or polka dot tape. There is a big gap between the speed capabilities of punched tape and magnetic tape, but there is also a big price differential in the equipments. The Burroughs electrostatic printing technique appears to be the answer to fill this gap in speed capabilities and equipment cost.

APPLICATION TO OSCILLOGRAPH

IT'S EASY TO VISUALIZE how this technique can be applied to a simple oscillograph. One of the experimental units built was for the Department of the Navy, Bureau of Aeronautics, for missile test telemetry. This is a multiple-channel oscillograph with selectively variable paper speeds up to 20 inches per second and having a row of 430 pins spaced evenly across the page. Channel widths can be arbitrarily selected for a given test and frequencies up to 150 cycles per second can be easily distinguished. Sampling rates up to 30 kc provide a beautiful trace at any paper speed, or input frequency. Of course, since there are no recording pens or galvanometers, there is no inertia problem, and hence, no overthrow or overshoot when responding to a drastic change in direction.

Other products are visualized based on the Burroughs electrostatic printing technique. A display device is currently under development for the Cambridge Research Center for use on the *433L* Weather Observing and Forecasting System. This device prints a series of large black matrix characters on a paper tape which can be read at a 12-foot distance in a dimly lighted room. The message, in this particular case, is a weather message of fixed format, 72 characters long. Input can be from computer, punched paper tape, polka dot tape, or magnetic tape. An entirely different message of 72 characters in length can be displayed in 1.2 seconds.

CONCLUSION

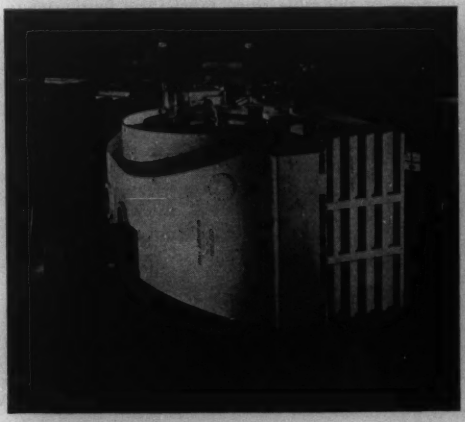
THE SURFACE has just been scratched in applications for this newly harnessed technique. Entirely different approaches to high-speed low-cost memory systems and recording problems are now deemed feasible. It has been strongly intimated that this technique is approaching the "ultimate" in high-speed printing for computers and communications systems.

40-Foot Mill Machines Turbine Section

Shown being machined on a 40-foot mill in the shops of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., is this giant section of a low-pressure turbine for use as part of a 340-mw 3,600/1,800-rpm close-coupled steam turbine-generator unit, to be No. 4 in the Astoria station of the Consolidated Edison Company, New York City.

Steam conditions for this unit, one of two which are being supplied to Consolidated Edison by Allis-Chalmers, are 2,000 pounds per square inch, gauge, 1,050/1,000 degrees F, and 2.0 inches of mercury absolute exhaust pressure.

Both units incorporate many improved design features to control expansion and minimize distortion in the high-temperature elements. Each unit has two rows of 46-inch exhaust blades, and both the 3,600-rpm and 1,800-rpm generators are fully supercharged, with rotors and stators conductor-cooled.



Design of Polyethylene-Insulated Multipair Telephone Cable

A. S. WINDELER

In designing telephone cable, the engineer must take numerous factors into consideration in order that the desired transmission properties may be realized. Thus certain predetermined mechanical and electrical characteristics must be built into the cable.

CABLES are designed to have characteristics which will make them suitable for a particular use or purpose. In the case of telephone cable, the purpose is primarily to transmit information at voice and carrier frequency during an expected life of approximately 30 years. To achieve these ends, certain mechanical and electrical characteristics must be built into the cable. Mechanical characteristics include resistance to environmental factors such as heat, cold, wind, lightning, moisture, sunlight, and oxygen, as well as resistance to damage by rodents and insects. Possible damage by workmen is also a factor. Other desirable mechanical characteristics involve factors of convenience of manufacture, installation, and joining.

The electrical characteristics include such things as adequate dielectric strength and freedom from crosstalk, and, of course, the all-important transmission properties. The purpose here is to consider only the design of cable so that the desired transmission properties may be obtained. In the case of the multipair cable, this boils down to adjusting the dimensions of the conductors and the insulation so as to obtain the desired resistance, inductance, capacitance, and conductance of the cable pairs. From these four primary constants, the secondary parameters of nonloaded circuits, namely the propagation constant and characteristic impedance, may be calculated. Moreover, with the primary constant data and the loading coil resistance, inductance, and spacing, the secondary constants of loaded circuits may be determined.

Cost is, of course, one of the fundamental considerations of any cable design. It involves an evaluation of such factors as availability and cost of the material selected, reliability of supply and probable price trend, and serviceability as compared to existing materials, etc. These considerations lie beyond the scope of the present article, which deals specifically with problems of design for obtaining the desired electrical characteristics.

The problem then, is to determine the dimensions which will give the desired primary constants. In the final analysis, this means determining the way in which the primary constants vary as the dimensions are changed.

Only the design of solid polyethylene-insulated multipair cable will be considered here, and only the voice-frequency primary constants will be discussed.

At voice frequencies we are interested mainly in the capacitance and resistance of the pairs. This is so because the secondary parameters of nonloaded circuits are dependent only on these constants and the frequency of transmission. In the case of loaded circuits, the inductance of the cable pairs plays only a small part in determining the secondary constants. The effect is quite small because the inductance of the loading coils far outweighs that of the cable pairs. With polyethylene-insulated cable, conductance has negligible effect in either case. This is true because of the remarkably low power factor of polyethylene. For convenient reference, the equations[1] which express the secondary constants in terms of the primary constants are given in the Appendix.

Let us now consider the problem of determining the voice-frequency resistance, inductance, and capacitance from the dimensions of the conductors, and the insulation. For this purpose, a representative voice frequency will be taken as 1,000 cycles per second.

At this frequency, for the wire sizes of interest, namely 19, 22, 24, 26 AWG, the a-c resistance of a cable pair is equal to the d-c loop resistance. For copper wires at 68 F this becomes

$$R = \frac{0.1095}{d^2} \qquad (1)$$

where

R = the resistance in ohms per mile

d = the conductor diameter in inches

Such simplicity is possible only because the skin effect, and certain proximity effects, so important at carrier frequencies, are negligible at voice frequencies for the wire sizes being considered.

For the same reason, the formula for the inductance of cable pairs at voice frequencies is very simple, being the same as that of a pair of wires in free space,[2] namely

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The author is indebted to F. W. Horn for helpful discussions, to L. M. Rackson, E. O. Bauer, and E. Schultz for the electrical testing of cable samples, and to Mrs. B. M. Felderman for numerous computations.

$$L = 1.482 \log_{10} \frac{2S}{d} + 0.1609 \qquad (2)$$

where

L = the inductance in millihenrys per mile
S = the interaxial spacing of the wires
d = the diameter of the wires

The last term is the so-called internal inductance of the two conductors, which is a constant (0.1609 millihenry per mile) for all sizes.

One question which arises immediately is how to control the interaxial separation S of the wires of a pair. Fortunately, S is dependent primarily on the diameter over the dielectric, generally referred to as the DOD. This dimension can be controlled quite precisely during the extrusion of the insulation over the conductor. For small values of DOD, normally associated with the finer gauges, the value of S is exactly the same as the DOD. This simply means that the insulated conductors fit closely together with no space between them. For larger DOD values, normally associated with the heavier gauges, there will be a small gap between conductors as illustrated in Fig. 1. The extent of this gap depends upon the stiffness of the conductors and upon the tension and compression to which the core is subjected during manufacture and installation. Experience with solid polyethylene-insulated conductors has demonstrated that the average value of S for a given DOD can be obtained from the empirical relation expressed by the curve in Fig. 1.

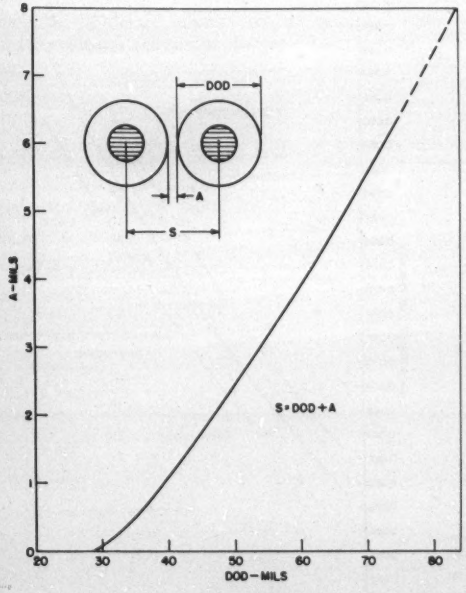

Fig. 1. Interaxial spacing as a function of diameter over the dielectric.

The problem of predetermining the capacitance is more difficult. To compute the pair capacitance, one needs not only the dimensions d and S, but also effective dielectric constant ε. The computation is further complicated by the fact that presence of the surrounding wires influences the capacitance of any pair. These

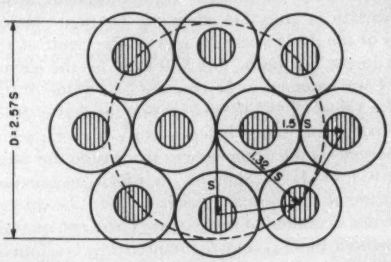

Fig. 2. Cable pair with surrounding wires as an effective shield.

surrounding wires form an electrostatic shield, the effective diameter of which is a function of S, the interaxial separation of the wires of a pair. This shield is indicated by the dotted circle in Fig. 2. The effective diameter of this shield is represented by the symbol D.

Thus, any pair in the cable becomes effectively a shielded pair, the capacitance of which can be calculated by an equation developed a number of years ago by Mrs. S. P. Mead.[3]

$$C = \frac{0.01944\,\varepsilon}{\log_{10}\left(\frac{2S}{d}\cdot\frac{D^2 - S^2}{D^2 + S^2}\right) - 0.1086\,\delta_{12}} \qquad (3)$$

where C = capacitance in microfarads per mile and δ_{12} is a series function of $d/2S$ and S/D. Values of δ_{12} for various values of $d/2S$ and S/D are plotted in Fig. 3.

The relation between S and D can be arrived at by the following reasoning. Consider any pair in the interior of a multipair cable. We may assume that the two wires of this pair are surrounded by an oval layer of eight wires as indicated in Fig. 2. It is apparent from the geometry that the distance from the center of the pair to the centers of the two nearest surrounding wires is equal to S, while the distance to centers of the two farthest wires is 1.5 S. The centers of the four remaining wires are 1.32 S distant from the center of the pair. If we average these eight distances we get 1.285 S as the mean radius of the layers of wires. As a first approximation, this may be considered to be one half the mean diameter D of the effective shield. The S/D ratio then becomes 0.389.

To obtain the dielectric constant ε, which is the remaining parameter involved in equation 3, we must refer to the measured capacitance of cables for which the ratio of $2S/d$ is known. As mentioned before, this ratio is obtained from the inductance measurements. For this study, data were obtained on eight cables of

four different gauges in the nominal 0.083 microfarad-per-mile capacitance range. These data are plotted in Fig. 4. The solid curve was calculated using a dielectric constant of 1.80. This seems to fit the data fairly well. The dotted curves above and below the solid curve were calculated using the dielectric constants of 1.90 and 1.70, respectively. These represent the extremes in deviation from the average. It is convenient to lump all variations into the dielectric constant, although some of the deviations may well be the result of variations in the S/D ratio. The S/D ratio for the curves in Fig. 4 was assumed to be constant at a value of 0.389.

The values of the dielectric constant and S/D ratio have been determined independently from capacitance measurements on a number of cables using the method described by J. T. Maupin[4] in which measurements are made of the mutual capacitance and the direct capacitance to ground of cable pairs. These two quantities represented by C_{mut} and C_g, respectively, are functions of S, d, D, and ε, that is $C_{mut} = f_1(S, d, D, \varepsilon)$ and $C_g = f_2(S, d, D, \varepsilon)$.

Because S can be determined from the inductance measurements and d is known for each gauge, the two equations can be solved for the two unknowns, D and ε. The average value of S/D obtained in this manner is 0.376. Since this method of obtaining the S/D ratio is not very precise, this is considered a good check on the value deduced from geometrical considerations. The average value of ε obtained in this manner is 1.83 which is considered a good check on the value of 1.80 obtained from the data in Fig. 4.

It will be noted that ε appears to be constant for all values of $d/2S$. For the condition where S equals the DOD (fine gauges and small DOD values) one would expect that the ε would increase as $d/2S$ is increased, since the ratio of the volume of insulation to the volume of air in the cable increases with an increase in $d/2S$ or an increase in d/DOD. However, the low capacitance cables (small $d/2S$ or d/DOD ratios) are normally made only in the 19-gauge size with a relatively large DOD (75 mils). Referring to Fig. 1, it can be seen that with such a large DOD value the air space between the insulated conductors of a pair is relatively large (6 mils). This tends to counteract the effect of the small d/DOD ratio. The net result appears to be a constant ε over the range of $d/2S$ being considered.

In designing a cable to have a given capacitance, one needs only to select the appropriate $d/2S$ ratio from Fig. 4. If the value d for the gauge selected is known, S can be calculated. From Fig. 1, one can then determine the DOD to which the wire should be insulated.

To complete the design of a cable it is necessary to know one further parameter, that is, the diameter of cable core to which a given number of pairs will build up. It is common practice in designing cable to allow a theoretical space or area for each pair in the cable. This theoretical area, measured in thousand circular mils (MCM), is known as the space per pair. For instance, it is known that 100 no. 19 AWG pairs having conductors with a DOD of 60 mils (S = 63.9 mils) will form a core 1.17 inches in diameter. The total area involved here is approximately 1.37 x 10^6 circular mils

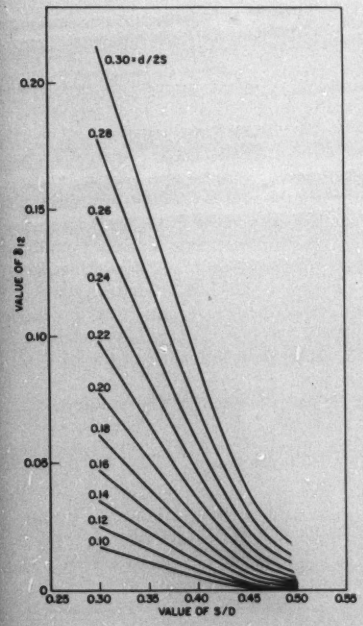

Fig. 3 *(left)*. δ_{12} as a function of $d/2s$ and S/D.

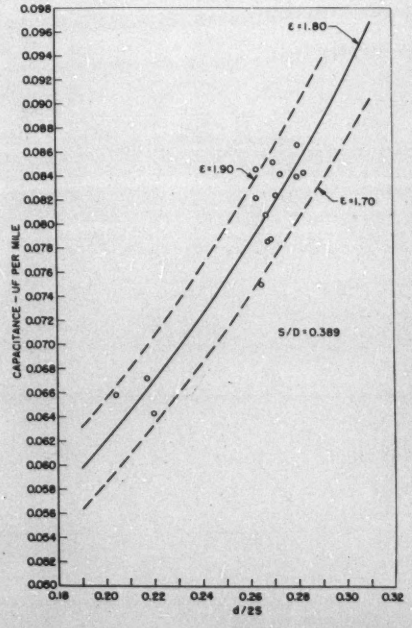

Fig. 4 *(right)*. Capacitance as a function of ratio of conductor diameter to interaxial spacing.

or 1,370 MCM. If we divide this number by 100 we get the space per pair, which is 13.7 MCM.

The exact space which pairs of a given size will occupy depends upon the tensions and pressures encountered in the twisting, stranding, and cabling operations. The following empirical formula will, however, serve as a guide in selecting the number of MCM to allow for a given size pair, that is, a given value of S:

$$\text{Space per pair} = 3.35\ S^2 \times 10^3 \text{ MCM} \qquad (4)$$

where S is the interaxial spacing in inches and is related to the DOD as indicated in Fig. 1. Having selected the space per pair, one must multiply it by the number of pairs in the cable, which gives the total area of the core in MCM. This area is then converted to circular inches and the square root extracted to obtain the diameter of the core in inches.

CONCLUSION

In the design of cables that will have certain transmission characteristics, the dimensions of the conductors and the insulation must be chosen so as to produce the primary constants which will give the desired characteristics. In the case of multipair cable at voice frequencies, the important primary constants are the resistance and the capacitance. The desired resistance can be obtained merely by selecting the proper gauge of conductor. However, choosing the dimensions of the insulation which will give the desired capacitance is more involved. An equation is given from which the capacitance of a multipair plastic-insulated cable can be calculated. Values for the constants in this formula have been obtained by empirical means. Finally, to complete the design information, an empirical equation is given for the size of the cable core in terms of the insulation diameter.

Appendix

The secondary constant in terms of primary constants is given in the following:

Nonloaded Cable

Propagation constant:

$$P = \sqrt{(R+j\omega L)\ (G+j\omega C)}$$

$P \approx \sqrt{j\omega RC}$ at voice frequencies

Characteristic impedance:

$$Z_0 = \sqrt{\frac{R+j\omega L}{G+j\omega C}}$$

$Z_0 \approx \sqrt{\frac{R}{j\omega C}}$ at voice frequencies

Loaded Cable

Propagation constant per mile:

$$P' = \frac{2}{N}\tanh^{-1}\sqrt{\frac{2Z_0 \tanh \frac{NP}{2} + Z_C}{2Z_0 \coth \frac{NP}{2} + Z_C}}$$

Mid-section characteristic impedance:

$$Z'_0 = Z_0\sqrt{\frac{2Z_0 + Z_C \coth \frac{NP}{2}}{2Z_0 + Z_C \tanh \frac{NP}{2}}}$$

where

R = Resistance in ohms per mile

L = Inductance in henrys per mile

G = Conductance in mhos per mile

C = Capitance in farads per mile

$\omega = 2\pi f$, where f = frequency in cycles per second

$j = \sqrt{-1}$

N = Number of miles per loading section

Z_C = Loading coil impedance

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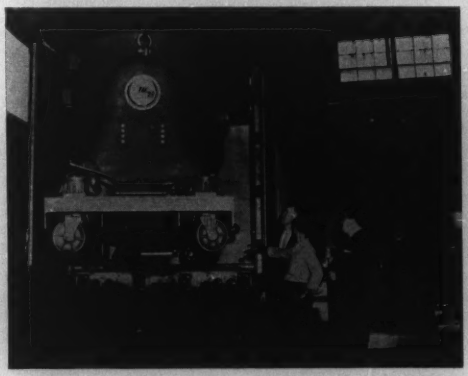
2. Electromagnetic Waves (book), S. A. Schelkunoff. D. Van Nostrand Company, Inc., Princeton, N. J., 1943, p. 284.

3. Shielded Cable System, Mrs. S. P. Mead. *U. S. Patent no. 2,086,629*, Apr. 14, 1936.

4. Measurements in Multipair Cables. J. T. Maupin. *Bell System Technical Journal*, New York, N. Y., vol. 30, July 1951, pp. 652-67.

Vibration Test System



Huge vibration test system, manufactured by MB Electronics, New Haven, Conn., is shown prior to shipment to Sperry Gyroscope Company, Great Neck, N. Y., where it will be used in testing components for high-performance aircraft and missiles. Each of the two vibration exciters is capable of shaking components weighing as much as 2,150 pounds at accelerations up to 10 g. The giant shakers weigh 35,000 pounds each, and the electronic power amplifier and associated equipment weigh in at approximately 22,000 pounds.

Abstracts of AIEE Technical Papers

References which accompany these abstracts are to the current bimonthly publications. These will comprise the same page references to each part of AIEE *Transactions*, vol. 78, 1959, when it becomes available in the Spring of 1960, as follows:

Part I. Communication and Electronics (C&E)
Part II. Applications and Industry (A&I)
Part III. Power Apparatus and Systems (PA&S)

COMMUNICATION DIVISION

59-70. Engineering Aspects of TASI. *K. Bullington, J. M. Fraser.* The number of telephone circuits carried by submarine cable systems can be doubled by using the normal gaps in speech to interpolate additional conversations. TASI is a high-speed transmission and switching system that assigns a talker to a channel as soon as he starts to talk and disconnects him when he pauses, if someone else needs the channel. Switching from channel to channel may occur many times during a typical call, but the effect on transmission quality is negligible because the switching time is fast compared with the syllabic rate. (C&E, July 1959, pp. 256-60.)

59-71. Electrical Protection for Transistorized Equipment. *D. W. Bodle, J. B. Hays, Jr.* Discharge gaps commonly used to protect telephone apparatus having a dielectric strength of at least 500 volts rms will not adequately protect equipment employing transistors and miniature components against foreign potentials. Semiconductor diodes are being used successfully to supplement gaps to provide lower voltage protection.

This paper discusses the conditions of exposure and the nature of foreign potentials in communications and power circuits; the electrical characteristics and surge duty ratings of semiconductor protection diodes; methods of applying semiconductor devices to typical equipment circuits; and methods and devices for protecting sensitive a-c powered equipment from hazardous surges from the power source. (C&E, July 1959, pp. 232-37.)

GENERAL APPLICATIONS DIVISION

59-251. Modern Systems of Traffic Control as Applied to the Seaboard Air Line Railroad Company. *J. R. DePriest.* The paper contains information concerning the longest segment of railroad in the world equipped with traffic control where trains are operated by signal indication. A technical discussion, which includes formulas and table, explains why a single track railroad using traffic control can handle a large number of trains in each direction without the need of double track. The requisites for the communication system for traffic control is outlined and a description of how this information is extended to the field by the use of carrier is given. (A&I, July 1959, pp. 168-72.)

59-252. Traffic Control for Railroads. *G. W. Baughman.* Two main developments permitted the railroads to handle their greatly increased traffic during World War II: (1) the diesel electric locomotive and (2) centralized traffic control. Each of these developments required the other for its most efficient operation. This paper deals with the novel application of carrier frequencies which permitted the large expansion of the amount of territory that could be controlled economically from one centralized traffic control office. A new concept of traffic control machine has been developed which permits the dispatcher to handle much larger territories than previously. This system constitutes an important component in the considerations being given to the operation of crewless trains. (A&I, July 1959, pp. 173-76.)

INDUSTRY DIVISION

59-231. A Stability Criterion for Nonlinear Systems. *Y. H. Ku, A. A. Wolf.* Given $x(t)$ the solution of a nonlinear differential equation such that $x(t) = 0$ (e^{st}). Then $x(t) \to 0$ as $t \to \infty$ if and only if the convex singularity hull (CSH) of the transform $X(s)$ is entirely in the left half plane. The CSH is constructed by joining the points of singularity of the transform $X(s)$ in the s plane. In linear systems, the CSH is composed of poles for lumped parameter systems. In nonlinear systems, the CSH is composed of singularities which are not necessarily poles. The new stability criterion holds for nonlinear as well as linear systems. (A&I, July 1959, pp. 144-48.)

59-233. Limit-Cycle Stability Study of a Feedback Control System by a New Describing-Function Technique. *H. J. Harrington.* A new describing function technique for determining the limit-cycle stability of mildly nonlinear control systems is developed in this paper. The method utilizes a closed-loop stability diagram parametrically plotted as functions of two independent linear-system parameters. Substantial advantages in interpretation and flexibility are realized over the usual open-loop diagrams which allow only loop gain to be adjusted. Numerical examples, including the treatment of two simultaneous nonlinearities, are given in the analysis of a typical aircraft roll control system. (A&I, July 1959, pp. 129-34.)

POWER DIVISION

58-952. Economic Complementary Operation of Hydro Storage and Steam Power in the Integrated TVA System. *R. N. Brudenell, J. H. Gilbreath.* This paper analyzes those problems of integrating thermal plants with a hydro storage system that pertain to an assured firm power supply and to minimizing annual production costs. The treatment progresses from a simple system to a complicated system that includes multiple-cost thermal power sources and a market for both firm and interruptible power. The future hydro supply is assumed to be quite unpredictable, with a repetition of each historical flow year equally likely. The paper describes the development of "economy guide curves," which are used by TVA in choosing between stored hydro energy and thermal generation. (PA&S, June 1959, pp. 136-56.)

58-1175. Grounding and Cathodic Protection of Pipes for Pipe-Type Feeders. *F. E. Kulman.* Grounding the steel pipe containing high-voltage insulated conductors provides protection from induced voltages, lightning, and switching surges, and provides a low resistance path for the return of line-to-ground fault currents. However, effective grounding may result in difficulties in the application of cathodic protection to buried sections of the pipe. Various existing methods of meeting the requirements of grounding and corrosion protection are discussed and criteria are presented for judging the usefulness of methods which may be developed in the future. (PA&S, June 1959, pp. 184-92.)

58-1202. Selecting Damping Resistors for Vacuum Switches in Bank-to-Bank Switching. *J. Zaborsky, J. W. Rittenhouse, E. L. Luehring.* The design equations for damping resistors in bank-to-bank switching are derived and summarized in a form convenient for the designer. Precalculated curves are presented. Limitations on peak current, peak temperature, and peak overvoltage on the resistor are considered as design specifications. (PA&S, Apr. 1959, pp. 18-23.)

58-1308. Fundamental Concepts of Incremental Maintenance Costs as Used by Ohio Edison Company. *D. B. Zelenka, R. H. Travers.* As load is allocated to a generator, certain additional maintenance costs are incurred, which can be construed to be incremental. Since the heat transfer and wearing surfaces of a power plant increase directly with unit size, the importance of evaluation of incremental maintenance increases with larger generating stations. The emphasis on economic power dispatching increases the importance of methods to determine their increments. It is impossible to find one solution to apply to all situations, but factors affecting the increment, such as high and low load maintenance, incremental coal-handling maintenance, and fuel cost data adjustment can be studied in detail in particular plants to provide practical methods of evaluation. Studies which provide examples of such evaluation are presented for examination. (PA&S, June 1959, pp. 163-65.)

58-1311. A Utility's Functional Evaluation Tests for High-Voltage Stator Insulation. *A. W. W. Cameron, M. Kurtz.* Tests have been developed to provide a utility with means of comparing the critical qualities of different makes and types of high-voltage stator insulation. Full co-operation has been afforded by North American and overseas manufacturers. A voltage-endurance test was chosen as indicative of ionization resistance, which has been found the most important factor in life of insulation for short-bore water-wheel generators. A test-machine has been built to reproduce and accelerate the thermal and mechanical cycling which are more important in the life of steam-turbine generator insulation. The test installations also provide for study of various operating and inspection problems. (PA&S, June 1959, pp. 178-84.)

58-1312. Experience in Analysis of D-C Insulation Tests for Maintenance Programming. *F. R. Schleif, L. R. Engvall.* The respective components of leakage current and absorption current may be easily determined from the data of conventional insulation tests. The determinations are made by matching templates to the log-log plots of d-c charging current versus time. The segregation avoids confusion where increase of one component has been offset by decrease of the other. Examination of the pure leakage-current component facilitates diagnosis of mechanical integrity of insulation. A plot of experience data indicates the pure absorption-current component to be related to age. Experience with the analysis has disclosed means of avoiding several extraneous influences on results. (PA&S, June 1959, pp. 156-62.)

58-1318. Computing Iron Losses in Fractional-Horsepower Induction Motor Design. *C. E. Linkous.* This paper presents an equivalent circuit and a calculation procedure for computing iron losses, for both line frequency and tooth rotational frequencies, in single-phase induction motors. It is judged to be an optimum for the situation of a standard punching being designed into many different motors using high-speed digital computers. With the possible exception of the effects of skew on the iron losses, no new theory is involved. (PA&S, June 1959, pp. 175-78.)

58-1336. Report on Present-Day Practices of Handling Incremental Maintenance Costs as They Apply to Economic Dispatch of Power. *AIEE Committee Report.* The paper summarizes the results of a questionnaire on the general subject of maintenance costs applicable to incremental generation which was circulated to the electric utility industry by the AIEE Working Group on the Application of Incremental Heat Rates in the Economic Dispatch of Power. The answers to the questionnaire are presented in tabular form together with comments and discussion relative to the interpretation of the tabulated results. The results of the survey show a wide variation between companies in the procedures followed in developing incremental maintenance costs, in the manner of expressing incremental rates, etc.; nevertheless, 95% of the companies reporting include maintenance as an item of incremental operating cost when interchanging energy with other systems. (PA&S, June 1959, pp. 279-82.)

59-1. Characteristics of Induction Motors with Permanent-Magnet Excitation. *J. F. H. Douglas.* This paper shows that through use of an induction motor with permanent-magnet excitation, nearly unity power factor can be realized. The proposed structure is a modification of a German motor. Probable usefulness will have to wait until stronger permanent magnets become available. With the usual stator and a ring-shaped cage, the proposed motor has an inner idler member carrying the magnets and traveling at synchronous speed. (PA&S, June 1959, pp. 221-25.)

59-23. Automatic Control of Internal Angle on Synchronous Machines. *V. A. Kinitsky.* This paper proposes to use a rotor displacement angle indicator for excitation control. Normally, excitation control is provided by a voltage regulator, but if the internal angle of the machine approaches a critical value, the internal angle indicator takes over control of excitation, keeping a prescribed angle and preventing the machine from falling out of step. Three methods are proposed for the action of the internal angle control on the excitation of the machine. The application of angle control permits utilization of total capability of the machine. Changes in system reactances are taken into consideration automatically so that manual resetting of the regulator is unnecessary. Direct and indirect acting voltage regulators in conjunction with angle control can be used for synchronous machine operation in the dynamic stability region. (PA&S, June 1959, pp. 225-31.)

59-26. Jointing Polyethylene-Insulated Submarine Cables. *D. W. Kitchin, O. S. Pratt.* Equipment and methods for injection molding of joints like those in the Transatlantic Telephone Cable and similar cables are described. Major features are (1) butt scarves on original insulation, (2) injection gun using cold slugs, (3) water-cooled mold ends with arrays of holes between hot and cold sections for smooth temperature transition, (4) symmetrical 2-sided injection, (5) improvement in processing injection stock, (6) rigorous inspection and continuous training of operators, and (7) d-c breakdown tests to 500 kv on qualification joints. (PA&S, June 1959, pp. 239-48.)

59-27. Classification and Standardization of Cable and Limiters for Secondary Network Systems. *I. Matthysse.* To assure proper co-ordination of limiters and cable insulation in secondary network systems, the AIEE Limiter Task Group has set up a procedure for classifying cable insulation according to its damage temperature, and the classes *L260* and *L220* were adopted for insulations having damage temperatures of at least 260 C and 220 C, respectively. Standard time–current characteristic curves of insulation damage and of limiters operation were adopted for the *L260* and *L220* classes. Most insulation and limiters used today for secondary network systems were found to be of the *L260* class and very little interest was expressed in the *L220* class. (PA&S, June 1959, pp. 315-27.)

59-121. Modern Large Steam Turbines and Generators. *C. C. Franck, Sr., J. W. Batchelor.* Modern large steam turbine–generator units form the backbone of our electric utility system. Although they represent separate pieces of equipment, they must be skillfully combined in order to form a complete electric generating unit. This paper discloses and gives a solution to problems encountered when combining these elements. A discussion as to how the equipment designed for one component fits into the requirements of the other component is highlighted. Although one of the units is basically thermal and the other electrical, there are many design features which have a common fundamental solution. The approach to these solutions is described. Trends in operating conditions and trends in rating are discussed. A number of modern steam turbine–generator units are described and illustrated. (PA&S, June 1959, pp. 307-15.)

SCIENCE AND ELECTRONICS DIVISION

59-48. Digital Computer Design of Pulse Transformers. *P. E. Lego, R. L. Green, J. M. Banic, Jr.* This paper describes a digital computer program which designs pulse transformers to specification. The program is based upon the trial-and-error method of design. The design is initiated by the statement of the specifications desired and completion of certain additional forms containing input data for the computer. A completed design, or perhaps a family of designs, is automatically produced by the computer. The advantages of the program are: reduced design time allowing faster quotes and delivery, availability of intermediate designs so parameter variation effects are easily studied, production of consistent designs, and release of design engineers from routine calculations. (C&E, July 1959, pp. 217-20.)

59-75. Three Decades of Progress in Electrical Insulation. *L. J. Berberich.* The last 30 years covers a period marked by outstanding advances in certain areas of the electrical insulation field. Specifically, the paper records briefly the progress made in (1) the theoretical phases of the field, (2) the development of new insulating materials, (3) the revision of the electrical insulation temperature standards, and (4) the application of insulating materials to power equipment. The new insulation temperature standards developed during this period have resulted in revolutionary methods of thermally rating insulating materials. The progress made in the development of materials, in particular, has stimulated radical advances in design, reliability, and performance of electric equipment. (C&E, July 1959, pp. 237-48.)

Design Features of Large Steam Turbine–Generators

S. C. BARTON
MEMBER AIEE

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THE CONTINUING RAPID GROWTH in the kva ratings of 3,600-rpm generators, as shown in Fig. 1, has been made possible by the development of many new features, and the resulting designs have some distinctive characteristics. The purpose of this article is to describe several of these features and characteristics.

Conductor cooling has extended the feasible output for 3,600-rpm generators far beyond that which has been possible with conventional hydrogen cooling, and has effectively removed temperature considerations as the major design limitation. The General Electric Company's experience in designing, building, and testing generators employing different types of conductor cooling has confirmed the anticipated advantages of liquid cooling of tubular strands for the stator coils, and the multiflow "gap pickup" type of gas cooling for the rotor. A typical generator with these features is shown in longitudinal section in Fig. 2, which also illustrates the basic simplicity of such designs, with single-stage fans and ventilation circuits similar to those used in conventional generators. The inherently high excitation requirements necessitate high-current collectors, which have been developed very successfully for carrying direct currents up to 3,500 amperes or more. These currents are several times the maximum used in conventionally cooled generators.

A new and greatly improved high-voltage insulation for stator coils has been developed, employing micamat, glass cloth backing, and a new duplex bonding resin. As compared with the previous modified-bitumen mica-flake insulation, the new Micapal insulation is a thermosetting system with higher dielectric strength, greatly increased mechanical strength and chemical stability and inertness, and greater temperature endurance.

A new type of internal spring foot core suspension has been developed for the very largest generators requiring double stator frames to meet shipping limitations. This suspension is doing an excellent job of isolating the magnetic vibration of the stator cores in some 30-odd generators to which it has been applied.

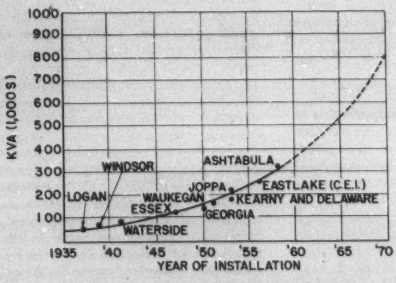


Fig. 1. Growth of 3,600-rpm turbine–generators.

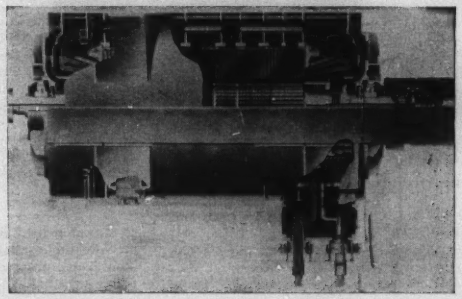


Fig. 2. Longitudinal section of a liquid-cooled generator.

Mechanical improvements in rotors include accurate predetermination of critical speeds for obtaining low sensitivity to unbalance at running speed, and systematic balancing methods for obtaining smooth operation at all speeds. In addition, major improvements in forgings have been achieved by the modification of alloying elements and heat treatment for obtaining increased toughness (measured by impact transition temperatures) without sacrifice of magnetic properties.

Hydrogen systems have been continually improved and simplified. The industry has had experience with a few gas explosions, which occurred while the units were out of service, with resulting mechanical damage to the generator only, and of not too serious nature. These explosions, supplemented by factory tests, suggest the possibility of detonations with rather high, but exceedingly brief, pressure waves. Renewed emphasis has been put on precautions that will help prevent explosions. A number of new techniques have been developed for this purpose.

Certain voltage ratings are appreciably more economical than others for specific generator kva ratings because of several basic interrelationships among design factors. The simplified presentation of this complex problem here should be of practical interest to those who wish to understand the design engineer's choice of voltages for large generators.

Digest of paper 58-1108, "Design Features and Characteristics of Large Steam Turbine–Generators," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE–ASME National Power Conference, Boston, Mass., Sept. 29–Oct. 1, 1958. Published in AIEE *Power Apparatus and Systems*, Feb. 1959, pp. 1335-48.

S. C. Barton, J. A. Massingill, and H. D. Taylor are with the General Electric Company, Schenectady, N. Y.

INSTITUTE ACTIVITIES

Chicago Section Will Be Host to 1959 Fall General Meeting of AIEE

THE FALL GENERAL MEETING of the AIEE will be held in Chicago, Ill., this year, on October 11-16, 1959, with headquarters at the Morrison Hotel. The technical program, inspection trips, and social activities will occupy the entire facilities of the Morrison during the meeting. The meeting will be held concurrently with the National Electronics Conference (NEC), with provision for joint registration. Headquarters for the NEC will be in the Sherman Hotel.

The Chicago Section extends a hearty welcome to all members, their families, and guests. Chicago, being the center of one of the greatest industrial regions of the world, is easily accessible by automobile, rail, or air from all parts of the continent. In addition, Lake Michigan affords pleasant temperatures as well as many recreational facilities.

At the general sessions, to be held on Monday afternoon, October 12, the Institute's Medal for outstanding service in electrical engineering education will be awarded to Dr. G. S. Brown, dean of engineering, Massachusetts Institute of Technology. In addition, the initial presentation of the William M. Habirshaw award to W. A. DelMar, retired, and the Maurice E. Leeds award to H. B. Brooks, retired, will be made.

On Thursday, October 15, there will be an Eta Kappa Nu luncheon for all AIEE and Eta Kappa Nu members. This luncheon will be held in Parlors B, C, and D in the Morrison Hotel at 12:15. A speaker of general interest will follow the luncheon.

A large and varied technical program has been planned, with special attention given to rotating machinery and nucleonics. The nucleonic session will include papers covering the evaluation studies of reactor concepts recently completed by leading consultant firms for the Atomic Energy Commission.

United Air Lines Photo

CHICAGO, THE SITE of the 1959 Fall General Meeting, is always a gracious host city. The view above is looking north on Michigan Avenue with the Wrigley Building on the left and Tribune Tower on the right. The old water tower can be seen in the background.

Social Activities

A reception tea and hospitality hour will open the social activities on Sunday afternoon, October 11, from 4:00 to 6:00 p.m. in the Cotillion Room. The hospitality hour is sponsored by the Chicago Section of the AIEE for members and their families. Members of the Ladies Activities Committee will be present to welcome the wives.

The Fall Frolics will be held on Wednesday, October 14, in the Terrace Casino and, as in previous years, top entertainment will be provided in addition to a good dinner. Dancing will follow the entertainment. Tickets are $12.50 per person and may be purchased from J. R. Warren, Royal Electric Manufacturing Company, 1122 E. 87th St., Chicago 19, Ill.

Ladies Program

The ladies' hospitality headquarters will be in Suite 7 (Room 705) at the Morrison Hotel. Starting Monday morning, it will be open from 9:00 a.m. each day except during special ladies functions. Coffee and rolls will be served each morning until 10:30 a.m. In addition, a variety of special activities has been planned as follows:

Sunday—Reception in the Cotillion Room of the Morrison Hotel, 4:00 p.m.—6:00 p.m.

Monday—Dessert card party in the Walnut Room at 1:00 p.m. Tickets are $1.50 each.

Tuesday—Sightseeing tour of the south side of the City of Chicago, terminating at the South Shore Country Club. Luncheon will be served, followed by Sulie Harand presenting the musical play, "Flower Drum Song." Busses will provide transportation back to the hotel. Tickets are $3.50, including cost of transportation.

Wednesday—Brunch and fashion show from 9:30 a.m. until 11:00 a.m., in the Carousel Room atop the Morrison Hotel. Tickets are $1.75.

Thursday—Luncheon in the Art Institute at 12:15 p.m., followed by a conducted tour and lecture of the world-famous museum. Tickets are $2.25.

The generosity of many manufacturers has made these special activities available

at a price of only half the actual cost. Tickets will be available at the ladies' hospitality headquarters. There will be a registration fee of $2 for the ladies.

Hotel Reservations

J. C. Granahan is in charge of hotel room reservations and should be contacted in case assistance is needed. Address requests to J. C. Granahan, Hotel Room Reservations Committee, Illinois Bell Telephone Company, 208 West Washington St., Chicago 6, Ill.

Should any problems concerning room accommodations arise during your visit, contact J. C. Granahan or one of his assistants.

It is suggested that in order to secure good accommodations, the reservation and rate cards enclosed with the mailed announcement be sent as soon as possible, directly to the Morrison Hotel. If the card is mislaid or lost, write to the reservation manager, Morrison Hotel, Madison and Clark Streets, Chicago 2, Ill. Be sure in making requests for reservations to mention the AIEE Meeting.

The Morrison has set aside a large number of rooms for this General Meeting. If a member decides at the last minute to attend, there is still a good chance that rooms will be available at this hotel.

Definite rooms will not be reserved until arrival. If rooms at rates requested are not available, a room at the next higher rate available will be assigned.

Please indicate on reservation cards the time of arrival. This is necessary if a member plans to arrive after 6:00 p.m. A room will be held for such a member, no matter what time after 6:00 p.m. he may arrive. Payment for this night will be charged to such a member.

If correspondence with the hotel regarding room reservations is necessary, please mail a copy of the letter to Mr. Granahan so that matters can be expedited. The Morrison Hotel will acknowledge all room reservations. If an acknowledgement is not received after a reasonable length of time, write to the hotel, sending a copy to Mr. Granahan.

Inspection Trips

Many varied and informative trips have been planned for AIEE members attending the Fall General Meeting.

A VIEW IS SHOWN of the high-voltage laboratory of Hubbard & Company at McCook, Ill. The high-voltage and high-current generators will be demonstrated during this tour.

Tuesday morning, October 13 (8:30 a.m.—12:15 p.m.), Fisk Station of Commonwealth Edison Company. Fisk Station, located on the Chicago River, is the oldest generating plant of the Commonwealth Edison Company. The first unit, a 5,000-kw General Electric vertical turbine-generator, was put in regular operation on October 2, 1903. In 1910, the station consisted of ten 10,000-kw vertical units. Since then all of these units have been retired. At present, the station consists of six units, ranging in size from 25,000 kw, installed in 1914, to a 325,000-kw ultramodern cross-compound turbine-generator and a boiler of 2.1 million pounds per hour steaming capacity, that features any combination of pulverized coal and gas firing.

The tour will also include an auditorium session at which the Dresden project will be discussed. This 180-mw nuclear unit is scheduled for service July 1, 1960.

Tickets are $2 each. A maximum of 40 persons can be accommodated on this bus trip.

Tuesday afternoon, October 13 (2:00 p.m.—3:00 p.m.), Commonwealth Edison Company Dispatching Office. Commonwealth Edison Company's new $700,000 automatic dispatching system which controls 92% of this company's 5,000-mw capability will be open for inspection to small groups.

The equipment to be seen is an automatic dispatch system which economically controls 37 turbine-generators, maintains proper flow of power interchange with connecting utilities and continually matches output to system demand. This office is the control center for major transmission and generation on the entire Commonwealth Edison system and switching operations inside the City of Chicago.

Tickets are free of charge. This will be a walking trip for a maximum of 15 persons. (Additional trips will be scheduled if required.)

Tuesday afternoon, October 13 (2:45 p.m.—6:45 p.m., and 6:30 p.m.—9:30 p.m.), Hubbard & Company Electrical Research Laboratory. Hubbard and Company opened its new high-voltage Electrical Research Laboratory during 1958. The laboratory is located in McCook, a southwest Chicago suburb, about 13 miles from the loop. The laboratory is designed for developing and testing high capacity and high-voltage equipment for power systems, and includes extensive mechanical facilities for designing and testing pole line construction items.

The tour will feature demonstrations utilizing impulse generators, a 600-kv 60-cycles test set, and short-circuit testing equipment in the outdoor power laboratory. Transportation will be by bus starting from and returning to the Morrison Hotel. Two trips are offered, limited to 40 persons each. Total trip time will be about 2½ hours. Tickets are $2 each.

THIS is the final assembly area of the La Grange plant of Electro-Motive Division of General Motors. Visitors will also see, in operation, the 6,000-kw automatic generating plant developed by Electro-Motive.

Wednesday morning, October 14 (8:30 a.m.—12:30 p.m.), Electro-Motive Division of General Motors Manufacturing Facilities at La Grange, Ill. Those visiting the La Grange, Ill., plant of Electro-Motive Division of General Motors will see in operation the 6,000-kw automatic generating plant developed by Electro-Motive for economic handling of utility system peak loads.

Features of the compact plant, including fast start and unattended operation will be demonstrated to AIEE visitors as part of the scheduled plant tour.

AIEE Future Meetings

AIEE-ASME National Power Conference*
Muehlebach Hotel
Kansas City, Mo.
September 27-October 1, 1959

AIEE-IRE Industrial Electronics Conference*
Mellon Institute
Pittsburgh, Pa.
September 30-October 1, 1959

ECPD 27th Annual Meeting
Wade Park Manor
Cleveland, Ohio
October 5-6, 1959

Fall General Meeting*
Morrison Hotel
Chicago, Ill.
October 11-16, 1959

AIEE-IIT-IRE-NU-UI National Electronics Conference*
Sherman Hotel
Chicago, Ill.
October 12-14, 1959

Fall Textile Conference*
Hotel Charlotte
Charlotte, N. C.
October 15-16, 1959

Machine Tool Conference*
Hotel Sheraton-Cleveland
Cleveland, Ohio
October 19-21, 1959

Mid-America Electronics Conference*
Hotel Muehlebach
Kansas City, Mo.
November 3-5, 1959

AIEE-IRE-ISA National Automatic Control Conference*
Sheraton Hotel
Dallas, Texas
November 4-6, 1959

Control Systems Components Conference*
Sheraton Hotel
Dallas, Texas
November 4-6, 1959

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference (Exhibits)*
Sheraton Hotel
Philadelphia, Pa.
November 10-12, 1959

Appliance Technical Conference*
Biltmore Hotel
Los Angeles, Calif.
November 16, 1959

Magnetism and Magnetic Materials Conference*
Sheraton-Cadillac Hotel
Detroit, Mich.
November 16-19, 1959

AIEE-ASTM High-Voltage Cable Insulation Conference*
Governor Clinton Hotel
New York, N. Y.
November 18, 1959

AIEE-IRE-ACM Eastern Joint Computer Conference
Statler Hilton Hotel
Boston, Mass.
November 30-December 3, 1959

AIEE-IRE Mid-West Circuit Theory Conference*
Marquette University
Milwaukee, Wis.
December 1-2, 1959

AIEE-NEMA Second National Conference on Application of Electrical Insulation
Shoreham Hotel
Washington, D. C.
December 8-10, 1959
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—October 5)

AIEE-IRE-ASQC Symposium on Reliability and Quality Control
Hotel Statler
Washington, D. C.
January 11-13, 1960
(Abstracts—closed, final papers—Oct. 15)

Winter General Meeting
Hotel Statler
New York, N. Y.
January 31-February 5, 1960
(Final date for †TP—Nov. 2, ‡CP Syn.—Nov. 17, CPMs—Nov. 27)

AIEE-IRE-U of P Solid State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 10-12, 1960.
(Final date for papers—Oct. 9)

Engineering Aspects of Magnetohydrodynamics Conference
University of Pennsylvania
Philadelphia, Pa.
February 18-19, 1960
(Final date for †TP—Nov. 20, ‡CP Syn.—Dec. 4, CPMs—Dec. 15)

AIEE-IRE-AEC-NBS Scintillation Counter Conference
Shoreham Hotel
Washington, D. C.
February 25-26, 1960
(Final date for †TP—Nov. 27, ‡CP Syn.—Dec. 11, CPMs—Dec. 22)

EJC Nuclear Congress
New York, N. Y.
April 3-8, 1960

Southwest District Meeting
Shamrock-Hilton Hotel
Houston, Texas
April 4-6, 1960
(Final date for †TP—Jan. 4, DPMs—Jan. 29)

East Central District Meeting
Daniel Boone Hotel
Charleston, W. Va.
April 12-14, 1960
(Final date for †TP—Jan. 13, DPMs—Feb. 5)

AIEE-ASME-IRE Automatic Techniques Conference
Sheraton-Cleveland Hotel
Cleveland, Ohio
April 18-20, 1960
(Final date for †TP—Jan. 19, ‡CP Syn.—Feb. 2, CPMs—Feb. 12)

Great Lakes District Meeting
Pfister Hotel
Milwaukee, Wis.
April 27-29, 1960
(Final date for †TP—Jan. 28, DPMs—Feb. 22)

North Eastern District Meeting
Sheraton Biltmore Hotel
Providence, R. I.
May 2-4, 1960
(Final date for †TP—Feb. 2, DPMs)—Feb. 26)

Electrical Problems in the Cement Industry Conference
Pfister Hotel
Milwaukee, Wis.
May 17-19, 1960
(Final date for †TP—Feb. 17, ‡CP Syn.—March 4, CPMs—March 14)

Summer General Meeting
Chalfont-Haddon Hall
Atlantic City, N. J.
June 19-24, 1960
(Final date for †TP—March 21, ‡CP Syn.—March 31, CPMs—April 15)

Pacific General Meeting
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs—June 3)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 9-14, 1960
(Final date for †TP—June 10, ‡CP Syn.—July 21, CPMs—August 5)

*Final date for submitting papers—closed

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Author's Guide*
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York, N. Y.

Prior to the *MU60* demonstration, visitors will be taken on a tour of Electro-Motive's manufacturing facilities housed on a 331-acre tract of land near La Grange where they will see various electrical manufacturing processes developed by Electro-Motive, including machine taping of traction motor armature coils, silicone insulation of main field and interpole coils, and machine forming of cross connectors and armature coils.

Tickets are $2 each. This will be a bus trip for a maximum of 80 persons.

Wednesday afternoon, October 14 (1:30 p.m.–5:30 p.m.), Panellit Products Plant at Skokie, Ill. Panellit, Inc., Skokie, Ill., has pioneered in many firsts, such as the industrial multiple alarm system (Panalarm), graphic process panel, industrial digital logger-scanner (Panascan), and others. With an engineering staff specialized in centralized control rooms, Panellit is composed of several sections, namely:

Control Systems and Panels: In this division, one will see boards under construction for boiler, turbine, and generator controls.

Panalarm Annunciators: In a shop uniquely designed for this application, one will see Panalarm Annunciators being assembled, wired, and individually tested, before going through the final functional test.

Information Systems (ISI): The visitor will then tour a recently completed section where a functional test will be made on the newest product–*609* information and computer system. This is the ultimate in combining data reduction with an internally programmed general purpose computer for static scanning, computing, and controlling of the process.

Tickets are $2 each. This will be a bus trip for a maximum of 40 persons.

Wednesday afternoon, October 14 (2:15 p.m.–3:15 p.m.), New Equipment of the Chicago and Northwestern Railroad. An inspection of America's push-pull suburban train and of a unique "bi-level" streamliner is planned during this tour. The inspection will be staged by the Chicago and Northwestern Railway Company at their terminal, Canal and Madison Streets, with L. E. Legg, electrical engineer of the railway, as host and sponsor.

THE North Western Railroad is now using many of these new "bi-level" coaches. In addition to the electrical features of these coaches, an inspection of the first "push-pull" suburban train is planned.

Chicago and North Western Railway

Both are "electric trains" in every sense of the word, with energy provided by diesel engines in the locomotives. Auxiliary generators in the locomotives of both trains provide power for lighting, air-conditioning, and even electric heating in the coaches. Undercar generators and troublesome steam pipes have been eliminated in the new trains.

In operation, the "push-pull" train moves toward Chicago with the locomotive at the rear end pushing the train. The engineer controls the train from a cab located at the head end of the leading car. Outbound from Chicago, the engineer transfers to the locomotive and the train is pulled in the conventional manner.

Tickets are free of charge. This is a walking trip for a maximum of 40 persons.

Thursday morning, October 15 (8:30 a.m.–12:30 p.m.), Chicago Harbor Authority. The Chicago Regional Port District facilities are located at Lake Calumet which unites the St. Lawrence Seaway with Chicago, the gateway to America's farm, business, and industrial heart. The Calumet harbor also links the nation's two main arteries of waterborne commerce, the Great Lakes–St. Lawrence Seaway system with the Illinois Waterway–Mississippi River System.

WITH THE OPENING of the St. Lawrence Seaway, an appropriate trip may be taken to the Chicago Regional Port District facilities. The freighter, "Manchester Explorer," is seen unloading English-built automobiles.

Calumet Studio

The harbor expects to handle 500 foreign ships this year. It has about 6,000 feet of ship dockage and 500,000 square feet of warehouse. Products from steel and autos to beer and olives are unloaded to be replaced by innumerable products including machinery, hides, and bubble gum.

The Calumet harbor at present has two grain elevators with capacity for 13 million bushels of grain. Visitors will inspect the fully automated dumping, conveying, storage temperature measurement, and ship loading control rooms.

Tickets are $2 each. This will be a bus trip for a maximum of 40 persons.

Thursday morning, October 15 (9:00 a.m.–10:00 a.m.), Underwriters' Laboratories, Inc. Underwriters' Laboratories, Inc., is chartered as a nonprofit organization without capital stock to establish, maintain, and operate laboratories for the examination and testing of devices, systems, and materials, to help reduce and prevent loss of life and property from fire, crime, and casualty.

During the inspection of the various laboratories, the AIEE members will see the testing of clothes driers and automatic washing machines; stalled rotor tests on inherent overload protection of motors; arc-rupture tests on motor controllers, enclosed switches, service equipment; endurance tests on thermostats; impact and implosion tests on television tubes; temperature tests on fluorescent lamp fixtures; normal and abnormal temperature tests on various types of cooking appliances and heaters; short-circuit tests on fuses; and temperature tests on signaling appliances and battery chargers.

In other laboratories, the members will see tests on air conditioners, refrigerators, explosion-proof electrical equipment, fire retardant paints, fire doors, and many other types of materials and equipment.

Tickets are 50¢ each. This will be a walking trip for a maximum of 20 persons.

Thursday afternoon, October 15 (1:30 p.m.–5:30 p.m.), Automatic Electric Company, North Lake, Ill. This plant is located on a 167-acre site, 15 miles west of Chicago's Loop, in North Lake, with a main building which covers 35 acres. The company manufactures and installs automatic telephone systems and other com-

munication systems for independent telephone companies, for business and industry, and also designs and manufactures a wide variety of electrical control components and systems for use in the products and processes of industries in every field. The company is part of General Telephone and Electronics which operates one of the world's largest telephone systems serving more than 4 million telephones.

The proposed trip will include a visit to the General Telephone Laboratories which occupy a large area of the plant where products are designed and developed, and a trip through the main plant where these products are manufactured for telephone and industrial use.

Tickets are $2 each. This will be a bus trip for a maximum of 80 persons.

Thursday afternoon, October 15 (1:00 p.m.—6:00 p.m.), Argonne National Laboratories. The Argonne National Laboratory, the nation's senior atomic energy research and development center, is located approximately 25 miles southwest of downtown Chicago. Argonne's research laboratories and other facilities are spread over a 3,700-acre tract and are valued at more than $100 million.

The scheduled trip to Argonne will offer an opportunity to become acquainted with the Experimental Boiling Water Reactor (EBWR), a "prototype" for the electric-power-producing reactors. Originally designed for 20-mw thermal output, the EBWR has been operated at more than 60-mw (thermal) and with modifications now in progress is expected to produce 100-mw (thermal). You will also become acquainted with the Zero Gradient Synchrotron (ZGS), a proton synchrotron accelerator now under construction. The ZGS will be capable of producing ultrahigh-energy particles in the 10 to 15 billion electron volt range and will be used as a laboratory tool in the field of high-energy physics research. Visits to some of the experimental facilities and research reactors will be included as time permits.

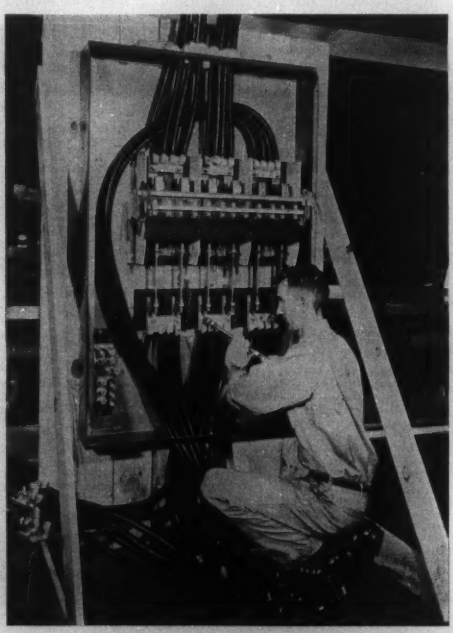
Tickets are $2 each. This will be a bus trip for a maximum of 80 persons.

Registration

Registration will be joint with the NEC this year. Those registering for the AIEE may also register for the NEC, if requested at the time of registration, without payment of additional fee. Those registering for NEC may also register for AIEE by payment of difference in registration fee. The registration fee will be $6 for members and $10 for nonmembers. Ladies will be charged $2, and students and guests will be admitted free.

Committee

The members of the 1959 Fall General Meeting Committee are: General Chairman, E. H. Finch; Vice-Chairman, D. H. Beal; Secretary, L. E. Randall; Treasurer, D. E. Skyelingstad; Fall Frolics, J. R. Warren; Hospitality, G. H. Robertson; Hotel Arrangements, R. J. Durkin; Finance and Budget, F. A. Larson; Sale of Papers, L. E. Ackman; Technical Program, R. J. Krekel; Ladies Activities, Mrs. P. R. Cassidy; Ticket Sales, D. J. Sommers; Registration, G. G. Law; Trips and Transportation, H. Fossum; General Session, G. L. Welch; and Publicity, S. Cluts.



AN Underwriters' Laboratories technician makes final preparations on a large enclosed switch before the temperature test. Switches of this type also get an endurance test, in order to assure reliability of mechanical operation and electrical overload tests.

The tentative program of the Fall General Meeting follows:

Monday, October 12

9:00 a.m. High-Energy Plasmas and Particles—I

CP.* Modern Magnetic Accelerators. *H. S. Snyder*, Brookhaven National Laboratory.

CP.* The Quest for Thermonuclear Power. *R. G. Mills*, Princeton University.

CP.* Electric Space Propulsion. *J. C. Evvard*, National Aeronautics and Space Administration.

9:00 a.m. Rotating Machinery

59-683. The Polyphase Induction Machine with Solid Iron Rotor. *N. Kesavamurthy, P. K. Rajagopalan*, Indian Institute of Technology (Re-presented for discussion only).

59-131. Synthesis of Induction Motor Designs on a Digital Computer. *C. G. Veinott*, Reliance Electric and Engineering Company (Re-presented for discussion only).

59-1098. Equations for Induction Motor Slip. *V. B. Honsinger*, Allis-Chalmers Manufacturing Company.

CP59-1134. Equivalent Circuit and Performance Prediction of the Double-Cage Induction Motor. *M. N. Abdel-Hamid*, Cairo University.

9:00 a.m. Communication Theory

CP.* A Class of Multiple-Error-Correcting Binary Codes for Nonindependent Errors. *P. Fire*, Sylvania Electronics Systems.

CP59-1076. On the Transmission of Information by Orthogonal Time Functions. *H. F. Harmuth*, Stromberg-Carlson Company.

59-1144. Network Response to Transient FM Inputs. *T. T. N. Bucher*, Radio Corporation of America.

59-1145. Effects of Nonlinearity on Propagation in Ionized Media. *G. I. Cohn*, Illinois Institute of Technology.

59-1146. Asynchronous Multiplexing. *J. E. Taylor*, General Electric Company (Re-presented for discussion only).

9:00 a.m. Protective Devices

59-1100. Surge Protection of Unit-Connected Generators. *K. H. Chang*, Arizona State University; *T. B. Thompson*, Oklahoma State University.

59-1096. The International Standardization of Lightning Arresters. *H. R. Armstrong*, Detroit Edison Company; *E. Beck*, Westinghouse Electric Company; *G. F. Lincks*, General Electric Company.

CP59-1196. Lower Cost, Improved Standardization Procedure, as Developed for Lightning Arresters. *G. F. Lincks*, General Electric Company.

CP.* Field and Laboratory Testing of Valve-Type Lightning Arresters. *R. C. Curto*, Detroit Edison Company.

59-1101. Report on Field Experience with Aerial Power Cable. Working Group of the Lightning Protective Devices Subcommittee of the Protective Devices Committee, *H. O. Stoelting*, chairman.

* Conference Papers will not be preprinted by the Institute; however, they may be available at the meeting at the discretion of the author.

9:00 a.m. Magnetics

59-1117. Effects of Ultrahigh-Temperature on Magnetic Properties of Core Materials. *M. Pasnak, R. Lundsten*, U. S. Naval Ordnance Laboratory (Re-presented for discussion only).

59-1204. The Effect of Flux Distribution on Iron Losses. *M. Schindler*, Radio Corporation of America.

59-1187. Some Multihorned Dilemmas in the Magnetic Field. *F. Avcin*, University of Ljubljana.

59-1188. On Expressions of Magnetic Hysteresis Characteristics. *S. Ohteru*, Waseda University.

2:00 p.m. Perception and Recognition

CP.* Digital Simulation in Perceptual Research. *E. E. David*, Bell Telephone Laboratories.

CP.* Networks for Gestalt Perception. *P. Greene*, University of Chicago.

CP.* An Electronic Device to Measure the Intelligibility of Speech. *J. C. R. Licklider, A. Bisberg, H. Schwartzlander*, Bolt, Beranek and Newman, Inc.

CP.* Image Simulation and Interpretation. *G. L. Meyers*, Astro Electronic Products.

CP.* A Review of the Perceptron Program. *A. E. Murray*, Cornell Aeronautical Laboratory.

Tuesday, October 13

9:00 a.m. High-Energy Plasmas and Particles—II

CP.* Principles of the Power Supply of a 12.5 Billion Electron Volt Proton Synchrotron. *G. O. Calabrese*, Argonne National Laboratory.

CP.* The Brown Boveri Betatron for Cancer Therapy and Material-Testing. *M. Semperi*, Brown Boveri and Company, Ltd.

CP.* Sector Focused Cyclotrons. *H. G. Blosser*, Michigan State University.

CP.* Electrical Power for an Alternating Gradient Synchrotron. *E. E. Shelton*, Brookhaven National Laboratory.

9:00 a.m. Electric Circuit Theory

59-1179. Two-Oscillator Scan Stability. *H. M. Joseph*, Johns Hopkins University.

59-1180. The General Form of Some Common Network Theorems. *C. Adamson, S. M. El-Sobki*, Manchester College of Science and Technology.

59-1186. Subarea Determination of the Capacitance of Cocentric Annular-Plate Capacitors. *D. K. Reitan, T. J. Higgins*, University of Wisconsin.

59-111. Capacitance of Parallel Rectangular Cylinders. *J. D. Horgan*, Marquette University (Re-presented for discussion only).

9:00 a.m. Rotating Machinery

59-1095. Voltage Harmonics of Salient-Pole Generators under Balanced Three-Phase Loads, Part I. *D. Ginsberg*, U. S. Army Research & Development Laboratories; *A. L. Jokl*, Continental Motors Corporation.

CP.* Voltage Harmonics of Salient-Pole Generators under Balanced Three-Phase Loads, Part II. *D. Ginsberg*, U. S. Army Research & Development Laboratories; *A. L. Jokl*, Continental Motors Corporation.

59-567. Dynamic Circuit Theory. *H. K. Messerle*, University of Sydney (Re-presented for discussion only).

59-1135. Reduction of Error and Null Voltage in Synchro Control Systems. *C. Lang*, Kearfott Company, Inc.; *C. Smith*, Servo Dynamics.

9:00 a.m. Transformers

59-1169. A New Approach to the Analysis of Impulse Voltages and Gradients in Transformer Windings. *L. Rabins*, General Electric Company.

CP.* Pseudo-Final Voltage Distribution in Impulsed Coils and Windings. *P. A. Abetti*, General Electric Company.

59-1170. Transformer Impedance Matching. *G. W. Iliff, F. A. Allehoff*, Bonneville Power Administration.

9:00 a.m. Data Communication

59-1106. An Error-Detection System for 5-Unit-Code Teletypewriter Transmission. *P. H. Barry*, Teletype Corporation; *A. L. Whitman*, Bell Telephone Laboratories, Inc.

59-1147. Detection of Transmission Errors in 5-Level Punched Tape. *R. Steeneck, H. F. Caley*, Western Union Telegraph Company.

59-1093. Data Processing as a Tool for Generalizing Communications Systems. *W. F. Luebbert*, U. S. Army Signal Research and Development Laboratory.

CP.* Parallel Transmission Data-Phone Subset. *M. A. Flavin*, Bell Telephone Laboratories.

CP.* Automatic Order Handling Using Low-Cost Data-Phone. *L. J. Sevebeck, P. J. Grunfelder*, Western Electric Company.

9:00 a.m. Radio Communication Systems and Television and Aural Broadcasting

CP.* A Microwave Radio Relay System with Demodulating Repeaters for Television and Multiplexed Telephony. *J. J. Clarke*, Radio Corporation of America.

CP.* Solid-State Lighting Equipment. *A. W. Malang*, American Broadcasting Company.

CP.* A Transistorized Television Receiver. *C. F. Otis*, Philco Corporation.

CP.* The National Stereophonic Radio Committee. *C. G. Lloyd*, General Electric Company.

9:00 a.m. Switchgear

CP59-1166. Induced Currents in Supporting Steel for a 10,000-Ampere Generator Open Bus. *G. K. Sebold*, Public Service Electric and Gas Company.

59-1124. Practical Solutions of Inductive Heating Problems Resulting from High-Current Buses. *N. Swerdlow*, General Electric Company; *M. A. Buchta*, Gilbert Associates, Inc.

59-513. Experience with Methods of Extending the Capability of High-Voltage Air Break Switches. *E. C. Rankin*, Appalachian Electric Power Company (Re-presented for discussion only).

CP.* Current Limiting Characteristics of a High Interrupting Capacity Cut-out. *R. P. Bridges, R. D. Okerberg*, Hubbard and Company.

2:00 a.m. Industrial and Commercial Power Systems

CP.* Electrical Thinking in the Pharmaceutical Industry. *L. E. Fickle*, Eli Lilly & Company.

CP59-1182. Matching Metalclad Switchgear to High-Voltage Industrial and Commercial Building Requirements. *C. H. Baker, J. J. Mikos*, S & C Electric Company.

CP59-1116. Overcurrent Protection for Industrial Power Systems. *D. V. Fawcett*, Canadian Westinghouse Company, Ltd.

CP59-1154. Electrical Record Drawings-Reams of Paper or Concise Up-to-Date Information. *G. L. Frank*, Polymer Corporation, Ltd.

2:00 p.m. High-Energy Plasmas and Particles—III

CP59-1195. The Model C Stellerator Facility. *N. W. Mather, R. G. Mills, J. G. Murray*, Princeton University.

CP.* Some Basic Concepts for Magnet Coil Design. *W. F. Gauster*, Oak Ridge National Laboratory.

CP.* Design of a 12-Mega Joule Capacitor Energy Storage Bank. *E. L. Kemp, T. M. Putnam*, University of California Los Alamos Scientific Laboratory.

CP.* The Electrical System for the Astron Injector. *F. Voelker*, University of California Radiation Laboratory.

CP.* Mega Joule Energy Sources for 10^{10}-Watt Pulses. *H. W. Van Ness*, University of California Radiation Laboratory.

CP.* Transformer Design for Toroidal Discharge Systems. *R. Carruthers*, United Kingdom Atomic Energy Authority.

2:00 p.m. Electric Circuit Theory

59-1090. Criteria and Tests for Realizability of the Inductance Matrix. *Y. Tokad, M. B. Reed*, Michigan State University.

CP.* Electronic Network Synthesis of Linear Algebraic Matrix Equations. *R. E. Horn*, Westinghouse Electric Corporation; *P. M. Honnell*, Washington University.

CP59-1202. Switching Circuit Synthesis by Transmission Matrix Manipulation. *C. A. Stapleton*, University of New South Wales.

CP.* Transient Analysis of Discrete Electric Networks by Two-Sided Dirichlet Transforms. *T. J. Higgins, M. Chen*, University of Wisconsin.

CP59-1185. Solution of D-C Rotating Machinery Problems by the Block Diagram Method. *H. Harrison*, New South Wales University of Technology and *S. Hariharan*, Trivandrum, India.

2:00 p.m. Rotating Machinery

CP59-1083. Functional Evaluation of High-Voltage Turbine-Generator Insulation Using a Generette Core Model. *E. A. Boulter*, General Electric Company.

59-976. A Variable-Speed Reversible Drive Using an Induction Motor. *G. Hausen, P. P. Biringer, G. R. Slemon*, University of Toronto (Re-presented for discussion only).

59-651. An Unusual Method for Replacing a Rotor Spider in a Water Wheel Generator. *W. R. Small, Jr.*, Pennsylvania Power and Light Company; *P. M. Bell*, Westinghouse Electric

Corporation (Re-presented for discussion only).

2:00 p.m. Transformers

59-1167. Internal Fault Characteristics of Gas-Insulated Transformers. *G. Camilli, L. G. Littlejohn, W. A. Wooldridge*, General Electric Company.

59-1168. Tank Pressures Resulting from Internal Explosions. *R. J. Ringlee, N. W. Roberts*, General Electric Company.

CP59-1133. Phase-Isolated LTC Transformers. *F. P. Kasper*, Oklahoma Gas & Electric Company; *J. S. Holtzinger, G. A. Wilson*, Pennsylvania Transformer Company.

2:00 p.m. Switchgear

CP.* The Effect of Current Chopping in Circuit Breakers on Networks and Transformers — I. Theoretical Considerations. *T. H. Lee*, General Electric Company.

CP.* The Effect of Current Chopping in Circuit Breakers on Networks and Transformers — II. Experimental Techniques and Investigations. *A. N. Greenwood*, General Electric Company.

CP.* Modern Instrumentation in a Short Circuit Research Laboratory. *E. F. Veverka, G. H. Manke*, Line Material Industries.

59-1150. Contact Erosion on a Capacitor Switch. *V. E. Phillips, J. C. Sofianek, A. L. Streater*, General Electric Company.

Wednesday, October 14

9:00 a.m. Nuclear Power Reactors—A Status Report—I

59-1132. Designs for Large Organic Reactor Power Plants. *G. H. Bosworth*, Bechtel Corporation; *W. E. Parkins*, Atomics International.

CP.* Boiling Water Reactor Power Plants. *L. F. C. Reichle*, Ebasco Services; *W. A. Hartman*, General Electric Company.

CP.* Nuclear Superheat Reactor Study. *J. West*, General Nuclear Engineering Corporation.

59-1155. A Design Study of Heavy Water Moderated Power Reactors. *F. W. McCloska, C. A. Halstat*, Sargent & Lundy.

CP.* Status of PWR Reactor Concepts and Summary. *D. Coburn*, Atomic Energy Commission.

9:00 a.m. Rotating Machinery

59-1137. The Calculation of Shaded Pole Motor Performance by the Use of a Digital Computer. *G. H. Sherer, G. E. Herzog*, Westinghouse Electric Corporation.

59-1138. The Theory and Design of a Very Slow Speed Reluctance Motor. *C. H. Lee*, Monroeville, Pa.

CP59-1139. Analysis of Series Generator Series Motor Drive. *R. W. Jones, A. U. Meyer*, Northwestern University.

58-1279. Iron Loss Calculations on Fractional Horsepower Induction Motors. *P. H. Trickey*, Wright Machinery Company (Re-presented for discussion only).

9:00 a.m. Radio Communication Systems

CP.* Co-ordination of Microwave Stations in Congested Areas. *B. A. Haynes*, Pacific Telephone & Telegraph Company.

59-1148. The Challenge of Universal Mobile Communications. *A. F. Culbertson*, Lenkurt Electric Company, Inc.

CP59-1088. Utilities Radio Regulation and Technical Advances. *J. C. Slothower*, Northern States Power Company.

CP59-1194. Intermodulation Testing of Multichannel Radio Systems. *M. E. Ferguson*, Lenkurt Electric Company.

59-1085. A Circular Polarization Duplexer for Millimeter Waves. *R. G. Fellers*, University of South Carolina (Re-presented for discussion only).

59-1091. Consideration in SSB/ISB Systems for Long Distance Radiotelegraph Communications. *W. Lyons*, Radio Corporation of America Communications, Inc.

9:00 a.m. Communication Switching Systems—I

59-1160. A Comparison of Sequential and Iterative Circuits. *E. J. McCluskey, Jr.*, Bell Telephone Laboratories, Inc.

CP.* A Ferrite Core Distributor and Memory System for a Small Electronic Telephone Switching System. *P. E. Osborn*, General Telephone Laboratories, Inc.

CP59-1131. Restrictors for Controlling Direct Distance Dialing Calls. *C. W. Freeman*, North Electric Company.

CP.* A New Small Crossbar Telephone System for P.B.X.s. *H. H. Abbott*, Bell Telephone Laboratories.

9:00 a.m. Transmission and Distribution

CP.* Another Look at Distribution Transformer Loss Ratios. *K. W. Klein*, Cleveland Electric Illuminating Company.

CP59-1087. Distribution System Conversion to 4160 Volts. *L. H. Herendeen*, Jackson & Moreland, Inc.

59-1174. Distribution Secondary Conductor Economics. *A. S. Anderson, V. A. Thiemann*, Ebasco Services, Inc. (Represented for discussion only).

CP.* A New Concept in Capacitor Design. *E. G. Hammer, G. A. Rynders*, Line Materials Industries.

59-1162. The Effect of Elevated Temperatures on Flash-Welded Aluminum-Copper Joints. *C. R. Dixon*, Alcoa Process Development Laboratories; *F. G. Nelson*, Alcoa Research Laboratories (Re-presented for discussion only).

9:00 a.m. Power System Communications

59-1099. Microwaves and Their Use in Power Systems. *S. C. Bartlett*. American Electric Power Service Corporation.

9:00 a.m. Industrial Control

CP59-1097. Fuseless Starters with 100,000-Kva and 150,000-Kva Interrupting Rating for 2,300-Volt and 4,600-Volt Motors. *C. A. Lister*, Square D Company.

CP.* A Package Control System for Wide Speed Range Shipboard Cargo Winch. *G. H. Piethe, R. S. Hamby*, Reliance Electric and Engineering Company.

CP.* Dynamic Positioning System as Applied to a Radar Antenna. *G. O. Pfeffer, F. G. Auch*, Reliance Electric and Engineering Company.

CP59-1171. A Straight Forward Design Method of a Thyratron D-C Motor System. *R. Cosaert*. University of Toronto.

2:00 p.m. Nuclear Power Reactors—II, Discussion and Symposium

(Papers presented in Morning Session.)

2:00 p.m. Applied Mathematics

59-1086. The A-C Resistance of Solid Magnetic Wires. *M. Kamal Gohar*, Cairo, Egypt.

59-1102. Conducting Sphere in Alternating Magnetic Fields. *H. Poritsky*, General Electric Company.

59-1128. The Computation of Correlation and Spectral Functions by Orthogonal Filtering. *E. G. Gilbert*, University of Michigan.

CP59-1189. The Generalization of Thevenin's Theorem, and its Application to the Analysis and Representation of Large Networks. *C. Adamson, B. D. Nellist*, Manchester College of Science and Technology.

2:00 p.m. Rotating Machinery

59-1114. An Analysis of Solid Rotor Machines —I: Operational Impedances and Equivalent Circuits. *A. J. Wood*, Hughes Aircraft Company (formerly with General Electric Company).

59-1115. An Analysis of Solid Rotor Machines —II: The Effects of Curvature. *A. J. Wood, C. Concordia*, Hughes Aircraft Company (formerly with General Electric Company).

59-1121. Synchronous Machine with Solid Cylindrical Rotor—Part II. *C. Concordia*, General Electric Company.

CP59-1082. Synchronous Motors with Permanent Magnets and Quadrature Flux Barriers. *J. F. H. Douglas*, Marquette University.

59-1140. Short-Circuit Torques in Turbine Generators. *P. I. Nippes*, Carrier Corporation.

2:00 p.m. Communication Switching Systems—II

CP.* Reconditioning a Water Damaged P.B.X. *R. E. Lindholm, J. L. Preston*, Illinois Bell Telephone Company.

CP.* Mobile Telephone Switching Equipment. *L. F. Bernhard, E. N. Duff*, Illinois Bell Telephone Company.

CP.* Electronic P.A.B.X. Equipment Utilizing Parametrons and Transistors. *K. Toyoda*, Fuji Tsushinki Seizo K.K., Tokyo, Japan.

CP.* Private Telephone Exchanges with Push Button Selection and Minimized Maintenance. *J. L. de Kroes*, N. V. Philips' Telecommunicatie Industrie.

2:00 p.m. Telegraph Systems

59-1111. Design Features of a New Frequency Shift Carrier Telegraph System. *M. L. Stephens*, Lenkurt Electric Company, Inc.

59-1107. Application of a New Carrier Telegraph System. *T. B. Collins, Jr.*, Automatic Electric Sales Corporation; *J. E. Pitts*, Lenkurt Electric Company.

59-1105. A Small Automatic Teletypewriter Switching System. *E. R. Shimmin*, Pacific Telephone & Telegraph Company; *R. A. Vanderlippe, A. L. Whitman*, Bell Telephone Laboratories, Inc.

CP.* Eddy Current Speed Control for Facsimile Telegraph Apparatus. *H. F. Burroughs*, Western Union Telegraph Company.

58-1143. A Character-Metered Transatlantic Switching System. *J. S. Coggeshall, P. Holcomb, Jr.*, Western Union Telegraph Company (Re-presented for discussion only).

2:00 p.m. Transmission and Distribution

59-1178. The Teinograph—A New High-Voltage Surge Recorder. *J. G. Anderson, R. U. Giacomoni*, General Electric Company.

59-1142. Determination of Lightning Response of Transmission Lines by Means of Geometrical Models. *F. A. Fisher, J. G. Anderson, J. H. Hagenguth*, General Electric Company.

59-1122. Ice Build-Up on Conductors of Different Diameter. *E. K. Lanctot, H. E. House*, Aluminum Company of America; *E. L. Peterson, E. S. Zobel*, American Electric Power Service Corporation.

CP59-1089. Digital Complex Arithmetic Analysis of Power System Problems. *A. J. Wood*, Hughes Aircraft Company (formerly with General Electric Company).

CP.* Bibliography on Extra-High-Voltage Systems—First Supplement. *P. A. Abetti*, General Electric Company.

2:00 p.m. Organization of Computer Activities for Electric Utility Engineering

CP.* Organizing to Use Computers. *H. N. Cantrell*, General Electric Company.

CP.* Practicability of Computer Usage for Utility Engineering. *L. L. Coombe*, Detroit Edison Company.

CP59-1197. Some Experiences in System Engineering Computing. *R. J. Brown*, Bonneville Power Administration.

CP.* Computer Problem Analysis. *R. Bruce Shipley*, Tennessee Valley Authority.

Thursday, October 15

9:00 a.m. Nuclear Reactor In-Core Instrumentation

CP59-1141. In-Core Ion Chambers for Reactor Safety and Control. *L. R. Boyd*, General Electric Company.

59-1184. Delayed Neutron Detection Methods Applied to the Detection and Location of Reactor Fuel Element Failures. *R. A. Dewes, J. C. Childs*, General Electric Company.

CP59-1110. Three-Dimensional Flux Distribution Measurements in a Power Reactor. *J. C. Childs, E. B. Fehr*, General Electric Company.

CP.* Design Approach to a Miniature Ion Chamber. *E. B. Hubbard*, General Electric Company.

CP59-1198. Methods of Improving In-Core Temperature, Flow, and Pressure Measurements. *J. A. McCann*, General Electric Company.

CP.* Design of Neutron Sensitive Thermopiles. *D. Robertson*, Leeds & Northrup Company.

CP.* Small Fission Chamber for Reactor Flux Mapping in the Interior of the Core. *G. Bouricius*, General Electric Company.

CP59-1199. Performance of In-Core Neutron Thermopiles for Power Reactors. *K. E. Watkins*, General Electric Company.

9:00 a.m. Wire Communication Systems

59-1175. Transistorized Multifrequency Ringing Generator. *J. F. Kostelich, B. W. Howald*, Lorain Products Corporation.

CP.* An All-Transistorized Trunk Carrier System. *F. H. Gardner*, Stromberg-Carlson Company.

CP.* A Transistorized Repeater for the *K31* Rural Subscriber Carrier System. *W. S. Woods*, Kellogg Switchboard and Supply Company, *A. R. Denz*, ITT Laboratories.

59-1104. The *K24A* Syncroplex Telephone Carrier System. *B. G. Coetsee, G. L. Curtis, J. W. Halina*, ITT Laboratories (Re-presented for discussion only)

9:00 a.m. Substations

CP59-1205. Large Downtown Substation. *M. L. Byrne*, Potomac Electric Power Company.

59-1126. New Distribution Substations for Direct 230-Kv to 12-Kv Transformation on the B. C. Electric Company System. *M. B. Callander*, B. C. Engineering Company Ltd.

59-1084. Automatically Programmed Remote Indication Logging for Use with Supervisory Equipment. *G. E. Guy, P. W. Schirmer*, General Electric Company.

CP59-1201. Grounding Electrode Potential Gradients from Model Tests. *H. R. Armstrong, L. J. Simpkin*, Detroit Edison Company.

9:00 a.m. System Engineering Studies by Digital Computers

59-1081. A New Method of Making Transmission Loss Formulas Directly from Digital Power Flow Studies. *E. E. George*, Ebasco Services, Inc.

CP.* Machine Processing of Data for D-C and A-C Digital Load Flow Studies. *H. D. Hurless, W. G. Hegg*, Bonneville Power Administration.

59-1092. Convergence of Iterative Load-Flow Studies. *J. E. Van Ness*, Northwestern University.

59-1127. Transient Stability Studies—III Improved Computational Techniques. *L. J. Rindt, R. W. Long, R. T. Byerly*, Westinghouse Electric Corporation.

9:00 a.m. Mining

CP.* A Review of Open Pit Mine Power Distribution Practices. *R. B. Bennett, M. A. Neslin*, General Electric Company.

CP.* Power Shovel Generator Excitation Systems. *D. E. Barber*, Bucyrus-Erie Company.

CP59-1173. Mining with A-C Power in Dosco Mines. *J. J. Laffin*, Dominion Steel and Coal Corporation, Ltd.

CP.* Remote Control of Underground Mining Machinery. *F. R. Hugus*, Joy Manufacturing Company.

9:00 a.m. Semiconductor Switching Devices and Applications—Part I

CP.* Factors in the Design and Application of Static Power Converters. *R. P. Putkovich*, Westinghouse Electric Corporation.

CP59-1203. Ultrasonic Frequency Power Generator Using Transistors. *Yin-Min Wei*, Westinghouse Electric Corporation.

CP.* High-Power Static Frequency Changers. *J. F. Roesel, Jr., A. F. Relation*, Westinghouse Electric Corporation.

2:00 p.m. Engineering and Testing of Digital Computers

CP59-1123. An Algorithm for Determining Minimal Normal Forms of an Incomplete Truth Function. *T. H. Mott, Jr.*, Radio Corporation of America Laboratories.

CP59-1129. An Approach to the Simulation of Computer Logic. *R. C. Baldwin*, Burroughs Corporation.

CP59-1190. A Magnetic Tape-to-Paper Tape Converter. *M. Ringer, L. Mintzer*, Minneapolis-Honeywell Regulator Company.

CP59-1172. Geometrical Positioning of Circuit Elements in a Computer. *U. R. Kodres*, International Business Machines Corporation.

2:00 p.m. Wire Communication Systems

59-509. A Transposition System for Carrier Systems up to 156 KC. *B. M. Kirkland*, Southern Bell Telephone & Telegraph Company.

CP.* Effects of Cable Irregularities on the Operation of Telephone Repeaters. *S. I. McCaron*, General Telephone Company of California.

CP.* Telephone Circuit and Equipment Impedances as They Affect Transmission Performance. *P. F. Radue*, Automatic Electric Company.

CP.* A Voice Band Transmission Measuring Set Using Swept-Band Techniques. *W. C. Lent*, Hallamore Electronics Company.

2:00 p.m. Excitation Systems

59-1113. An Electric Utility Brushless Excitation System. *E. C. Whitney, D. B. Hoover, P. O. Bobo*, Westinghouse Electric Corporation.

59-1108. Analytical Studies of the Brushless Excitation System. *R. W. Ferguson, R. Herbst, R. W. Miller*, Westinghouse Electric Corporation.

59-1109. New Instrument Systems for Recording Turbine Speed, Eccentricity, Expansion, and Vibration. *H. A. Harriman, D. M. Longenecker*, General Electric Company.

CP.* Excitation Systems. *V. J. Egan*, Allis-Chalmers Manufacturing Company.

2:00 p.m. Mining

CP.* Electrical Systems for Modern Coal Preparation Plants. *A. L. Reed*, Allen & Garcia Company.

CP.* Progress Toward On-Line Analysis of Raw Materials. *W. F. Loranger*, General Electric Company.

CP.* Electric Motor Maintenance and Field Testing. *L. L. Lipanye*, Reliance Electric & Engineering Company.

CP.* Portable Silicon Rectifiers for Mining Service. *W. A. Hodgson*, Westinghouse Electric Corporation.

2:00 p.m. Semiconductor Switching Devices and Applications—Part II

CP.* Trinistor A-C Switch. *E. Petrocelli*, Westinghouse Electric Corporation.

CP.* Controlled Rectifier Frequency Multipliers. *C. W. Flairty, B. D. Bedford*, General Electric Company.

CP.* Application of Controlled Semiconductors in the Paper Industry. *J. D. Grady*, Oxford Paper Company; *R. I. Goodwin*, General Electric Company.

CP.* Effects of Radiation on Semiconductor Rectifiers. *N. F. Bechtold*, U. S.

Army Signal Research and Development Laboratory.

CP59-1200. Proposed Definitions for Semiconductor Rectifier Components and Equipments. AIEE Rectifying Devices Working Group of the Service Subcommittee of the Semiconductor Metallic Rectifiers Committee, J. R. Thurell, Chairman.

Friday, October 16

9:00 a.m. Logical Design of Digital Computers

CP59-1119. Automatic Synthesis of Multifunction Networks. *T. C. Bartee*, Massachusetts Institute of Technology.

CP59-1191. Algorithms for Logical Design. *A. E. Randlev, J. P. Roth, E. C. Wagner*, International Business Machine Research Center.

59-1192. Simultaneous Logical Equations (Matrix Logic IV). *E. J. Schubert*, Burroughs Corporation.

CP.* Simplification of Logic Functions Containing a Large Number of Variables. *T. W. Sze*, University of Pittsburgh.

9:00 a.m. Relays and System Engineering

59-1163. Recent Practices and Trends in Protective Relaying. Survey of Relaying Practices Subcommittee of the Relays Committee, *H. J. Sutton*, chairman.

59-1164. Digital Solution of Short-Circuit Currents for Networks Including Mutual Impedances. *A. L. Toalston*, Commonwealth Associates Inc.

CP59-1206. Application of Digital Computer Program for Power System Fault Studies. *W. E. Marter, J. L. Koepfinger*, Duquesne Light Company; *C. W. King*, Westinghouse Electric Corporation.

59-1094. Bushing Potential Device with Multiple Ratings and Universal Application. *K. W. Eissmann*, General Electric Company.

9:00 a.m. New Computational Techniques in System Engineering—I

59-1159. The Application of Planning Criteria to the Determination of Generator Service Dates by Operational Gaming. *C. A. DeSalvo*, Westinghouse Electric Corporation; *C. H. Hoffman, R. G. Hooke*, Public Service Electric & Gas Company.

59-1176. Production Cost Calculations for System Planning by Operational Gaming Models. *K. M. Dale, W. H. Ferguson*, Westinghouse Electric Corporation; *C. H. Hoffman, J. A. Rose*, Public Service Electric and Gas Company.

59-1143. Mathematical Models for Use in the Simulation of Power Generation Outages—III. Models for a Large Interconnection. *C. J. Baldwin, D. P. Gaver*, Westinghouse Electric Corporation; *C. H. Hoffman, J. A. Rose*, Public Service Electric and Gas Company.

59-1130. A Model for Transmission Planning by Logic. *C. J. Baldwin, C. A. DeSalvo*, Westinghouse Electric Corporation; *C. H. Hoffman, W. S. Ku*, Public Service Electric and Gas Company.

9:00 a.m. Feedback Control Systems

CP59-1155. A Method for the Symbolic Representation and Analysis of Linear Periodic Feedback Systems. *E. O. Gilbert*, University of Michigan.

59-1151. Transient Response and the Stabilization of Feedback Amplifiers. *J. H. Mulligan, Jr.*, New York University.

59-1157. Analysis of A-C Servomotors Operated from Unbalanced, Nonsinusoidal Voltage Sources and Nonlinear Discontinuous Source Impedances. *E. R. Lind*, General Electric Company; *N. L. Schmitz*, University of Wisconsin.

59-1153. A Suppressed Carrier Signal Generator for Servo Instrumentation. *P. J. Pollard*, Chrysler Corporation (formerly with Vickers, Inc.).

59-1152. Investigation of the Feasibility of Designing Homing Aircraft Flight Control Systems for Minimum Probabilistic Error. *J. Zaborszky*, Washington University and McDonnell Aircraft Corporation; *J. W. Diesel*, McDonnell Aircraft Corporation.

59-1156. Control by Stochastic Adjustment. *J. E. Bertram*, International Business Machines Corporation (Re-presented for discussion only).

59-1158. Use of a Mathematical Error Criterion in the Design of Adaptive Control Systems. *C. Merriam III*, Massachusetts Institute of Technology (Re-presented for discussion only).

59-1181. Executive Controlled Adaptive Systems. *R. Staffin*, Polytechnic Institute of Brooklyn (Re-presented for discussion only).

2:00 p.m. Application and Theory of Computers and Computer Circuits

CP.* Synthesis of Symmetric Logic Functions Containing a Large Number of Variations. *T. W. Sze*, University of Pittsburgh.

CP59-1118. Automation of the Generation of Computer Diagnostic Routines. *K. Jacoby, H. Layton*, Philco Corporation.

59-1193. Ripple-Type Time Delay Networks Using Elliptic Functions. *J. R. Kiseda*, International Business Machines Corporation; *D. J. Ford*, University of Pittsburgh.

59-1125. Use of High-Speed Digital Computers to Study Performance of Complex Switching Networks Incorporating Time Delays. *Y. N. Chang, O. M. George*, North American Aviation, Inc.

2:00 p.m. Relays

CP.* Improved Protection of 4-Kv Feeders on the Baltimore Gas & Electric System. *W. W. Ward, Jr.*, Baltimore Gas and Electric Company.

CP.* Distribution Circuit Protection American Electric Power Company. *W. H. Johnson, T. J. Meier*, American Electric Power Service Corporation.

CP59-1165. Negative Phase Sequence Relays Applied to Paralleled Generators for Back-Up Protection. *W. J. Kerchner, Jr.*, Gilbert Associates, Inc.; *C. T. Abbott*, New England Gas & Electric System

2:00 p.m. New Computational Techniques in System Engineering—II

59-1177. Theory of Economic Selection of Generating Units. *K. L. Hicks*, Sargent & Lundy.

CP.* Automatic Load Projection and Substation Planning by Computer. *V. W. Ruskin, J. H. Drinnan, J. B. Claydon*, B. C. Engineering Company, Ltd.

59-1161. Strategy for Expansion of Utility Generation. *D. N. Reps*, Westinghouse Electric Corporation; *J. A. Rose*, Public Service Electric & Gas Company.

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2:00 p.m. Safety

CP.* Higher Residential Voltages—Safety Considerations. *H. H. Watson*, General Electric Company.

CP.* Electric Power and Common Sense (Film). Bay State Film Productions.

CP.* Mouth - to - Mouth Resuscitation (Film). *A. S. Gordon*, Children's Hospital.

CP.* Fire Hazards and Safety Techniques in Wiring Homes, Offices, and Factories. *R. Beach*, Robin Beach Engineers Associates.

Papers Invited For 1960 WJCC

A call for papers for the 1960 Western Joint Computer Conference (WJCC) next May 3-5 in San Francisco, Calif., has been issued by H. M. Zeidler of Stanford Research Institute, chairman of the technical program committee.

Following the successful pattern of the 1959 Conference, also in San Francisco, the program will cover a broad range of subjects of interest to engineers and management in the computer field.

Special emphasis will be placed on areas where new planning and new research and development programs are directed toward the growth of computer technology during the next decade.

"We particularly invite papers suggesting concepts and techniques in the newer areas, such as language translation, data retrieval, and self-teaching systems," Mr. Zeidler commented. "It is our intention that the Conference will serve effectively as a forum for papers and discussions covering the current state of the computer art—both analog and digital."

Submissions to the program are to be prepared on the basis of a 30-minute delivery, with extra time being available for discussion. Evaluation will be on the original draft, three copies of which must be directed to H. M. Zeidler at Stanford Research Institute, Menlo Park, Calif., before November 9.

Joint sponsors of the 1960 WJCC are AIEE, the Institute of Radio Engineers, and the Association for Computing Machinery.

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15th Annual NEC To Have 28 Technical Sessions, 260 Exhibits

THE 15TH ANNUAL National Electronics Conference (NEC) will be held October 12-14, 1959, in the Hotel Sherman, Chicago, Ill. Sponsors of the conference are: AIEE, the Illinois Institute of Technology, the Institute of Radio Engineers (IRE), Northwestern University, and the University of Illinois. Co-operating are: the Electronic Industries Association (EIA), Michigan State University, Purdue University, the Society of Motion Picture and Television Engineers (SMPTE), University of Michigan, University of Notre Dame, University of Wisconsin, and Wayne State University.

A total of 28 technical sessions will be held at the 3-day meeting. Approximately 260 exhibits of the newest in electronic devices and development will be on display.

Registration for NEC technical sessions and the exhibits will be in the lobby of the Hotel Sherman. The registration desk will be open from 4:00 p.m. to 8:00 p.m. on Sunday, October 11, and from 8:00 a.m. during the remainder of the conference.

The $3 registration fee covers all technical sessions and exhibits. Registration for exhibits alone is gratis.

NEC registrants may register for the AIEE Fall General Meeting, which will run concurrently at the Morrison Hotel, by the payment of the highest single fee which would apply. This can be done at the AIEE meeting or NEC. AIEE registration fees are $6 for members and $10 for nonmembers. Payment of AIEE registration will include NEC registration. NEC registration will be credited as $3 part payment on subsequent AIEE registration.

The tentative program follows:

Monday Morning, October 12

Adaptive Servomechanisms

Chairman: J. A. Aseltine, Space Technology Laboratories.

Trends in Adaptive Control Systems. *J. G. Truxal*, Polytechnic Institute of Brooklyn.

Multidimensional Adaptive Control. *J. E. Gibson*, Purdue University.

On the Philosophy of Adaptive Control for Plant Adaptive Systems. *M. Margolis, C. T. Leondes*, University of California (Los Angeles).

Use of Crosscorrelation in an Adaptive Control System. *G. W. Anderson, R. N. Buland, G. R. Cooper*, Purdue University.

Parametric Amplification

Chairman: John Bell, Zenith Radio Corporation.

Parametric Amplification with Solid-State Material and with Electronic Beams. *Glen Wade*, Stanford University.

Recent Advances in Electron Beam Parametric Amplifiers. *R. Adler*, Zenith Radio Corporation.

Magnetic Film Parametric Amplifiers. *A. A. Read, A. V. Pohm*, Iowa State College.

Optimum Figures of Merit of Varactors. *H. G. Rudenberg*, Transitron Electronic Corporation.

A Gold-Bonded Germanium Diode for Parametric Amplification. *W. P. Waters, S. T. Eng*, Hughes Products.

Audio

Sponsored by IRE Professional Group (PG) on Audio

Chairman: W. M. Ihde, General Radio Company.

Design and Use of RC Parallel-T Networks. *Gifford White*, White Instrument Laboratory.

Free Field and Pressure Calibration of Microphones by the Reciprocity Method. *R. W. Benson*, Armour Research Foundation.

A Transistorized Stereo Preamplifier and Tone Control for Magnetic Cartridges. *A. B. Bereskin*, University of Cincinnati.

A Compatible Tape Cartridge. *Marvin Camras*, Armour Research Foundation.

Hiss Reduction in Master Tape Machines. *A. A. Goldberg, Emil Torick*, Columbia Broadcasting System Laboratories.

Communications Systems

Sponsored by IRE PG on Communications Systems

Chairman: Charles Wittkop, Motorola.

Nonsynchronous Approach for Improved Communications Reliability. *C. H. Stewart, II, C. E. Baker, Jr.*, Bell & Gossett Company.

Performance Improvement in Single-Channel Voice Communication Radio System in Space. *L. P. Yeh*, Page Communications Engineers, Inc.

Synchronous Reception in a PCM/PS Telemetry System. *H. Raillard, H. N. Putschi*, General Electric Company.

Problems Encountered in Wide-Band Frequency Modulation. *D. D. Wilcox*, Ampex Corporation.

Noon Luncheon (Speaker to be announced.)

Monday Afternoon, October 12

Computers

Chairman: G. H. Leichner, University of Illinois

A High-Speed Electronic, Analog-to-Digital Encoder. *H. F. Lewis, J. J. Mielke*, Autonetics.

Elapsed Time Computation. *H. W. Abbott, V. P. Mathis*, General Electric Company.

High-Frequency Magnetic Film Parametrons for Computer Logic. *A. V. Pohm, A. A. Read, R. M. Stewart, Jr., R. F. Schauer*, Iowa State College.

Millimicrosecond Diode Capacitor Memory. *M. M. Kaufman*, Radio Corporation of America.

Electronic Devices

Chairman: J. J. Hupert, DePaul University

The Solar Battery. *Martin Wolf*, Hoffman Semiconductor Division.

Principles and Applications of Hall-Effect Devices. *M. Epstein, L. J. Greenstein, H. M. Sachs*, Armour Research Foundation.

Sintered Cadium Sulfide Photoconductive Cells. *E. Fischer, C. P. Hadley*, Radio Corporation of America.

Coherent Optical Data Processing Techniques. *L. J. Cutrona, E. N. Leith, L. J. Porcello*, University of Michigan.

Automatic Control

Chairman: R. G. Brown, Iowa State College.

Synthesis of Linear, Multivariable Feedback Control Systems. *I. M. Horowitz*, Hughes Aircraft Company.

Optimum Control through Tuned Sampling. *J. T. Tou*, Purdue University.

Extended Synthesis Techniques for Multipole Sampled Data Control Systems. *E. B. Slear*, Hughes Aircraft Company, and University of California (Los Angeles); *C. T. Leondes*, University of California (Los Angeles).

Three-Dimensional Phase Space Analysis. *L. P. Grayson, E. Mishkin*, Polytechnic Institute of Brooklyn

Perception and Recognition

Sponsored by AIEE Communications Theory Committee

Chairman: R. K. Hellman, Hazeltine Corporation

Digital Simulation in Perceptual Research. *E. E. David, Jr.*, Bell Telephone Laboratories.

An Electronic Device to Measure the Intelligibility of Speech. *J. C. R. Licklider, A. Bisberg H. Schwartzlander*, Bolt, Beranek and Newman, Inc. and General Electronic Laboratories, Inc.

Image Simulation and Interpretation. *G. L. Meyers*, Radio Corporation of America.

A Review of the Perceptron Program. *A. E. Murray*, Cornell Aeronautical Laboratory.

Networks for Pattern Perception. *Peter Greene*, University of Chicago.

Monday Evening, October 12

Recruiting of Scientific Personnel

Panel discussion sponsored by IRE PG on Engineering Management

Moderator: *J. D. Ryder*, Michigan State University.

Participants: *F. S. Endicott*, Northwestern University; *Edward Conley*, Conley Associates; *Harry Kentone*, Argonne National Laboratories; *R. C. Swander*, Cinch Manufacturing Company; *L. H. Good*, Radio Corporation of America.

Problems in Circuit Theory

Panel discussion sponsored by IRE PG on Circuit Theory

Moderator: *G. I. Cohn*, Illinois Institute of Technology.

Participants: *T. J. Higgins*, University of Wisconsin; *G. T. Flesher*, Bendix Aviation Corporation; *B. Saltzberg*, Space Technology Laboratories.

Education for Leadership

Panel discussion sponsored by IRE PG on Education

Moderator: *E. W. Ernst*, University of Illinois.

Participants: *A. D. Arsem*, Wurlitzer Corporation; *F. W. Braden*, Illinois Bell Telephone Company; *J. E. Gibson*, Purdue University; *A. H. Waynick*, National Science Foundation.

Tuesday Morning, October 13

Low Noise Devices

Chairman: R. J. Schwarz, Columbia University

Ultralow Noise Measurements Using a Horn Reflector Antenna and a Travelling-Wave Maser. *R. W. DeGrasse, B. C. Hogg, E. A. Ohm, H. E. D. Scovil*, Bell Telephone Laboratories.

The Use of Radio Noise from the Sun for Calibrating Radio Receiving Systems. *M. E. Armstrong, G. W. Swenson, Jr., R. L. Sydnor, H. D. Webb*, University of Illinois.

Reduction of Thermal Noise in Electron Beams. *C. M. Haaland*, Armour Research Foundation.

An Electrostatically Focused Travelling-Wave Tube for Wide-Band Amplification in L- and S-Band. *C. Cuccia, W. Johnson*, Radio Corporation of America.

Phase Shift through Travelling-Wave Tubes. *G. I. Cohn, Paul Yuen*, Illinois Institute of Technology.

Information Theory

Chairman: G. R. Cooper, Purdue University.

Information Capacity of Communication Networks. *L. S. Schwartz*, New York University.

A Probabilistic Model for Run-Length-Coding of Pictures. *Jack Capon*, Columbia University.

Optimum Linear Least Square Smoothing and Prediction with Finite Data. *R. Mittra*, University of Illinois.

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Some Computations of Error Rates for Selectively Fading Multipath Channels. *G. L. Turin*, Hughes Research Laboratories.

Transform-Ensemble Method for Analysis of Linear and Nonlinear Systems with Random Inputs. *Y. H. Ku*, University of Pennsylvania; *A. A. Wolf*, Stromberg-Carlson Company.

Numerical Analysis and Switching Theory

Chairman: L. W. Von Tersch, Michigan State University.

A Digital Computer Program for Reducing Logical Statements to a Minimal Form. *K. J. Butler, Jr., J. N. Warfield*, University of Kansas.

Multivalued Switching Algebras and Their Application in Digital Systems. *E. I. Muehldorf*, Westinghouse Electric Corporation.

On the Realizability of a Single-Contact Switching Function. *Omar Wing*, Columbia University.

Application of Sylvester's Theorem to Some Engineering Problems. *B. N. Garudachar*, Marquette University.

A Normalized Floating Point Significance Checking Program. *G. P. Weeg, J. Eidson*, Michigan State University.

Engineering Management

Sponsored by IRE PG on Engineering Management

Chairman: E. S. White, Warwick Manufacturing Company.

The Individual Case in Research Management. *E. H. Schulz*, Armour Research Foundation.

Project Selection in New Technical Fields. *A. H. Rubenstein*, Northwestern University.

Management of Product Development and Design Engineering. *W. B. Heinz*, Ampex Corporation.

A Military-Political Advisor—An Upcoming Need for Electronic Company Managements. *C. M. Bower*, Sealectro Corporation.

Occupational Hazards of Engineers as Managers. *J. R. Stovall, Jr.*, Remington Rand Univac.

Noon Luncheon (Speaker to be announced.)

Tuesday Afternoon, October 13

Solid-State Circuits

Chairman: J. J. Hupert, DePaul University.

Nonlinear Analysis of a Transistor Harmonic Oscillator. *D. O. Pederson, R. S. Pepper*, University of California.

Thermal Response of Transistors in the Avalanche Mode. *R. H. Beeson, I. Haas, V. H. Grinich*, Fairchild Semiconductor Corporation.

The Influence of Nonlinear Junction Capacitance on Transistor Rise and Fall Times. *R. P. Nanavati*, Syracuse University.

Semiconductor Diode Parametric Amplification. *E. L. Steele*, Hughes Products.

Electroluminescent Typewriter. *Theodore Hamburger*, Westinghouse Electric Corporation.

Communications Systems

Sponsored by IRE PG on Communications Systems

Chairman: Ransom Slayton, Teletype Corporation.

A Fully Electronic Private Automatic Telephone Switchboard. *J. G. Van Bosse*, General Telephone Laboratories.

The Application of Digital Computer Techniques to Electronic Telephone Switching Systems. *D. K. Melvin*, General Telephone Laboratories.

Message Protection in an Automatic Switching Center. *A. S. Rettig, H. P. Gerber*, Radio Corporation of America.

RCA's Automatic Switching Center. *J. L. Owings, T. L. Genetta, J. F. Page*, Radio Corporation of America.

Modern Production Techniques

Chairman: H. W. Farris, University of Michigan.

A Survey of the Future of Microcircuitry. *W. A. Adcock*, Texas Instruments Company.

Microcircuitry Applications of Evaporated Materials. *D. W. Moore*, Servomechanisms, Inc.

A Light Telemetry Molecular System. *G. Strull*, Westinghouse Electric Corporation.

Synthesis of Failure Indicating Modules. *D. H. Breslow*, Raytheon Manufacturing Company.

Magnetic Amplifier Applications

Sponsored by AIEE Magnetic Amplifiers Committee

Chairman: R. A. Raber, General Electric Company

Design for Manufacture of an Saturable Core Power Converter. *C. M. Bailey*, Bell Telephone Laboratories.

Transistor-Core Converter with High Input Voltages. *R. P. Massey*, Bell Telephone Laboratories.

Controlled D-C to D-C Voltage Step-Up with a Single Transistor. *R. E. Morgan*, General Electric Company.

Analog Computer Design of Magnetic Amplifiers. *L. A. Gregory*, Magnetic Controls.

Precise Control of High-Voltage D-C Using Magnetic Controls. *P. Convert*, Magnetics, Inc.; *M. Kramer*, Aluminum Company of America.

Static Control for a Mechanical Regulated 40-Kv Supply. *H. J. Abrams, J. Brubaker*, Westinghouse Electric Corporation.

Radio Communications

Sponsored by AIEE Radio Communications Committee

(Paper titles to be announced.)

Tuesday Evening, October 13

NEC Party. 6 p.m. cocktails, 7:15 p.m. dinner.

Wednesday Morning, October 14

Active Network Theory

Chairman: J. B. Cruz, Jr., University of Illinois.

Transformations of Active Networks. *N. DeClaris*, Cornell University.

Transistor Multiloop Feedback Amplifier Analysis. *L. M. Vallese*, Polytechnic Institute of Brooklyn.

The Active Constant-Resistance Lattice. *R. E. Thomas*, U. S. Air Force Academy.

Synthesis of Three-Pole, Narrow-Band Interstages. *J. J. Hupert*, DePaul University; *Anthony Sances*, American Machine and Foundry Company.

Transient Response as a Design Criterion for Stabilization of Feedback Amplifiers. *J. H. Mulligan, Jr.*, New York University.

Navigation and Guidance

Chairman: T. F. Jones, Jr., Purdue University.

Modern Navigation—A Survey by *C. S. Draper*, Massachusetts Institute of Technology.

A Glance at the Salient Points of Space Guidance. *Bernard Lee*, Emerson Electric Manufacturing Company.

The Synthesis of Velocity Inertial Navigation Systems. *F. V. Johnson*, General Electric Company.

High-Speed Inertial Platform Stabilization and Control. *Martin Finkel*, Northrop Corporation.

Heat Transfer and Fluid Flow for Airborne Navigation System. *J. F. Culverwell*, Northrop Corporation.

Radar

Chairman: D. L. Bitzer, University of Illinois.

Multiple Target Resolution of Monopulse Versus Scanning Radars. *S. F. George, A. S. Zamanakos*, U. S. Naval Research Laboratory.

Instrumentation for a Heat Budget Earth Satellite. *R. J. Parent, W. B. Swift*, University of Wisconsin.

Radar Target Angular Scintillation in Tracking and Guidance Systems Based on Echo Signal Phase Front Distortion. *D. D. Howard*, U. S. Naval Research Laboratory.

The Statistics of Radar Video After Linear and Nonlinear Mixing. *P. R. Dax*, Westinghouse Electric Corporation.

Ground-Breaking Ceremonies for the United Engineering Center

On Thursday, October 1, 1959, at 11:00 a.m., ground-breaking ceremonies will be held for the new United Engineering Center to be erected on United Nations Plaza between 47th and 48th Streets in New York City.

Herbert Hoover will be the principal participant in the ceremonies.

Instrumentation

Sponsored by IRE PG on Instrumentation

Chairman: S. A. Alessio, Bell & Gossett.

Electric Timing Set (Time Encoder). *J. C. Brazda*, Hallicrafters Company.

An Improved Transistorized Wave Analyzer. *John Petrack*, Hewlett-Packard Company.

Some New Techniques in Airborne Data Acquisition. *E. P. Brandeis, M. E. Harrison*, Ampex Corporation.

Technical Considerations for an Ultrasensitive Bridge to Measure RF Power and Voltage. *L. J. Greenstein, R. B. Schulz, M. Epstein*, Armour Research Foundation.

Instrumentation Techniques for Shock Time-of-Arrival Measurement. *H. M. Sachs*, Armour Research Foundation.

Noon Luncheon

(Speaker to be announced.)

Wednesday Afternoon, October 14

Circuit Theory

Chairman: D. O. Pederson, University of California.

Problems in Time-Domain Equalization in Pulse Transmission. *F. F. Kuo*, Bell Telephone Laboratories, Polytechnic Institute of Brooklyn.

Transmission and Hybrid Parameters for n-Port Networks. *L. P. Huelsman*, University of California.

The Circuitry for Scattering Matrix Synthesis. *K. L. Su*, Georgia Institute of Technology.

Transfer Function of RLC Grounded 2-Port with One Inductor. *S. L. Hakimi*, University of Illinois.

The Effect of Element Tolerances on Cascaded Four-Terminal Networks. *E. A. Worrell, Herman J. Yost*, Westinghouse Electric Corporation.

Antennas

Chairman: Morris Brodwin, Northwestern University.

An Investigation of the Feasibility of Obtaining a Constant Beamwidth Luneberg Lens. *L. K. DeSize, B. A. Woodward*, Airborne Instruments Laboratory.

A Compact Dual-Beam S-Band Beacon Antenna. *G. G. Chadwick, R. M. Phillips*, Aero Geo Astro Corporation.

A New Mathematical Approach for Linear Array Analysis. *D. K. Cheng, M. T. Ma*, Syracuse University.

The Mutual Impedance of Perpendicular Half-Wave Antennas. *D. R. Capps, D. L. Waidelich*, University of Missouri.

Far Field Antenna Pattern Calculations by Means of a General-Purpose Analog Computer. *A. I. Rubin, J. P. Landaver*, Electronic Associates, Inc., *H. Q. Totten*, General Electric Company.

Engineering Writing and Speech

Sponsored by IRE PG on Engineering Writing and Speech

Chairman: R. B. MacAskill, Cook Research Laboratories.

Patents and the Company Engineer. *Len Nierman*, Graf, Nierman & Burmeister.

The Relationship between Design Engineering and Engineering Publications. *L. H. Sprung*, Admiral Corporation.

How to Save Money on Artwork, *J. P. Davis*, Nelson Technical Enterprises, Inc.

System Analysis

Chairman: B. R. Myers, University of Waterloo.

A Comparison of Methods for the Analysis of Pulsed Linear Systems. *Herbert Freeman*, Massachusetts Institute of Technology.

Practical Applications of Signal Flow Graphs Using an Array of Nontouching Loops. *G. S. Axelby, R. H. Plath*, Westinghouse Electric Corporation.

The Analysis of Compensating Detectors for A-C Control Systems. *G. J. Murphy, J. F. Egan*, Northwestern University.

Improvement of Precision Control Using Open Loop Methods. *L. J. Johnson, S. E. Rauch*, Hallamore Company, and University of California (Santa Barbara).

The NEC will be host to some 40 students who are chairmen of student sections of AIEE and IRE in 13 midwestern states.

For the ladies, 3 days of activities have been planned by the NEC Ladies Activities Committee.

On Monday, October 12, the ladies will tour the Old Orchard Shopping Center and the Avon Cosmetics Plant. Luncheon at Old Orchard will include a fashion show. The Fran Allison television show will be viewed Tuesday, October 13. Luncheon will be served at the Imperial House, with a fashion show by Martha Weathered, followed by a tour of the Chicago Daily News. The ladies will visit the Don McNeill show on Wednesday, October 14. They will tour the Chicago Board of Trade, have luncheon at Trader Vic's, and tour the Silvestri Decorating Studio.

Ladies registration will begin Monday, October 12, at 9:30 a.m., at ladies headquarters, Hotel Sherman. The fee will be $6 per day for everything. Registration by individual days will be permitted. Coffee will be served from 10:00 a.m. every day at ladies headquarters.

Combined Control Conferences Listed, November 4-6, Dallas, Texas

THE NATIONAL Automatic Control Conference will be held November 4-6, 1959, in the Sheraton-Dallas Hotel, Dallas, Texas.

This conference is sponsored by the Institute of Radio Engineers Professional Group on Automatic Control (IRE-PGAC), with official participation by AIEE, the Instrument Society of America (ISA), and the IRE Professional Group on Industrial Electronics, and with the co-operation of the American Society of Mechanical Engineers (ASME), and the electrical engineering department of Southern Methodist University.

Principal conference officers are: L. B. Wadel, Chance Vought Aircraft, Inc., chairman; G. S. Axelby, Westinghouse Electric Corporation, technical program chairman; and J. M. Salzer, Ramo-Wooldridge, special program chairman.

Second Conference

Parallel to the second and third day of this conference, the AIEE Feedback Control Systems Committee, with other co-operating groups, is sponsoring a Control Systems Components Conference, also at the Sheraton-Dallas Hotel. Complete information on the latter conference may be obtained from D. D. Pidhayny, Ramo-Wooldridge, P. O. Box 90534 Airport Station, Los Angeles, 45, Calif. A single registration will cover both conferences.

A limited number of rooms has been set aside by the Sheraton-Dallas Hotel. The conference should be mentioned by name when hotel reservations are made. The registration fee is $5, but full-time students and faculty will be admitted for a $1 fee. No advance registration will be held. Registration will begin at the conference on Wednesday, November 4, at 7:30 a.m.

Abstracts Available

Abstracts of all technical papers of the National Automatic Control Conference will be available at the registration desk. Anyone desiring an advance copy of abstracts may send a self-addressed stamped envelope to M. L. Barnett, Apt. 208, 6255 Oram St., Dallas, Texas.

No proceedings volume will be published as such; however, it is intended that all papers be published by the *IRE Transactions on Automatic Control*, or, in a few cases, by other appropriate media.

Dr. A. C. Hall, automatic control pioneer and currently director of research at the Martin Company, Denver, Colo., will speak at a combined conference dinner meeting on Thursday, November 5, beginning at 7:30 p.m., in the Sheraton-Dallas Hotel. Admissions to the dinner will be limited, and advance reservations may be made with Prof. F. W. Tatum, electrical engineering department, Southern Methodist University, Dallas, Texas. Checks in the amount of $7.50 for each ticket should be made payable to the Institute of Radio Engineers. Tickets will be held at the registration desk.

The tentative technical program for the National Automatic Control Conference follows:

Wednesday, November 4

10.00 a.m. Session I—General

Chairman: J. E. Ward, PGAC chairman, Massachusetts Institute of Technology (MIT).

Welcoming Address: J. E. Jonsson, board chairman, Texas Instruments, Inc., and past president of the Dallas Chamber of Commerce.

Fundamental Theory of Automatic Linear Feedback Control Systems. *I. M. Horowitz*, North American Aviation.

General Approach to Control Theory Based on the Methods of Lyapunov. *R. E. Kalman*, RIAS, Inc.; *J. E. Bertram*, International Business Machines (IBM) Research Center.

Impact of Information on Control. *H. Chestnut, W. Mikelson*, General Electric Company.

2:00 p.m. Special Session—Control Problems of the Space Age

Chairman: J. M. Salzer, Ramo-Wooldridge.

Controlled Propulsion. *K. K. Dannenberg*, Army Ballistic Missile Agency.

Attitude Control of Space Vehicles. *C. R. Gates*, Jet Propulsion Laboratory.

Tracking and Path Control. *R. C. Booton, Jr.*, Space Technology Laboratories, Inc.

Control of the Human Environment. *Paul Webb*, consultant.

Thursday, November 5

9:00 a.m. Session II—Nonlinear Control Theory

Chairman: F. W. Tatum, electrical engineering department, Southern Methodist University.

Signal Stabilization of Self-Oscillating Systems. *R. Oldenburger*, Purdue University; *T. Nakada*, Tokyo Institute of Technology.

A Root Locus Method for the Analysis of Nonlinear Servomechanisms. *M. J. Abzug*, Douglas Aircraft Company, Inc.

Some Nonlinear Control Techniques Novel to Control Engineers Employed by a Biological Control System. *M. Clynes*, Rockland State Hospital.

On the Analysis of Bi-Stable Control Systems. *B. E. Amsler, R. E. Gorozdos*, Applied Physics Laboratory, Johns Hopkins University.

Effect of Power Source Regulation on the Response of Control System Amplifier. *R. J. Kochenburger*, University of Connecticut.

2:00 p.m. Session III—Automatic Control Devices and Systems

Chairman: A. R. Teasdale, Temco Aircraft Corporation.

Pendulous Velocity Meter Control Synthesis. *S. G. Shutt*, Autonetics, Division of North American Aviation, Inc.

The Analysis of Demodulating Compensating Networks. *G. J. Murphy, J. F. Egan*, Northwestern University.

Mathematical Models for Computer Control Systems. *T. M. Stout*, Thompson-Ramo-Wooldridge Products Company.

Multiloop Temperature Control System for Fluid Dynamics Facility with Long Transport Delays. *G. J. Fiedler, J. J. Landy*, Sverdrup and Parcel Engineering Company.

Some Linear and Nonlinear Aspects of Hot Gas Servo Design. *R. V. Halstenberg*, Convair.

2:00 p.m. Session IV—Control System Synthesis and Optimization (Organized by ASME)

Chairman: C. F. Taylor, Daystrom, Inc.

Topological Techniques for the Solution of Multiloop Sampled Systems. *R. Ash, W. H. Kim, G. M. Krane*, Columbia University.

Synthesis of Third Order Contactor Control Systems. *Irmgard Flugge-Lotz*, Stanford University.

On After-End-Point Motions of General Discontinuous Control Systems and Their Stability. *P. Seibert*, RIAS, Inc.

On the General Theory of Control Systems. *R. E. Kalman*, RIAS, Inc.

On Optimal Computer Control. *J. E. Bertram, P. E. Sarachik*, IBM Research Center.

The Second Method of Lyapunov in the Analysis and Optimization of Control Systems: Sampling Systems. (Presentation by title only.) *R. E. Kalman*, RIAS, Inc.; *J. E. Bertram*, IBM Research Center.

Friday, November 6

9:00 a.m. Session V—Automatic Flight Control

Chairman: (to be announced)

Adaptive Flight Control. (ISA paper) *O. H. Schuck*, Minneapolis-Honeywell Regulator Company.

Electronic Gain Control in Automatic Flight Control Systems. *W. Henn, A. S. Robinson*, Eclipse-Pioneer Division, Bendix Aviation Corporation.

Electronic Memory in Automatic Flight Control Systems. *D. Blanvett, A. S. Robinson*, Eclipse-Pioneer Division, Bendix Aviation Corporation.

Pulsed Controlled Integration in Automatic Flight Control Systems. *A. S. Robinson*, Eclipse-Pioneer Division, Bendix Aviation Corporation.

Reactor Wheel Attitude Control for Space Vehicles. *R. W. Froelich, H. Patapoff*, Space Technology Laboratories, Inc.

2:00 p.m. Session VI—Control System Design Techniques

Chairman: J. H. Mulligan, Jr., electrical engineering department, New York University.

D-Decomposition Analysis of Automatic Control Systems. (ISA paper) *R. W. Lanzkron*, Martin Company; *Thomas T. Higgins*, University of Wisconsin.

Optimization of the Adaptive Function by the Z-Transform Method. (AIEE paper) *S. S. L. Chang*, New York University.

Application of Pole-Zero Concepts to Design of Sampled Data Systems. *D. P. Lindorff*, University of Connecticut.

Synthesis of Feedback Systems with Specified Open-Loop and Closed-Loop Poles and Zeroes. *W. E. Carpenter*, Space Technology Laboratories.

Calculating Zeroes of Functions Arising in Various Control System Problems. (AIEE paper) *W. R. Evans*, Autonetics, Division of North American Aviation.

2:00 p.m. Session VII—Random Processes in Control Systems

Chairman: H. Freeman, MIT

Random Sampling: Its Effect on Spectral Density. *A. R. Bergen*, University of California.

A Procedure for Synthesizing Linear Time-Varying Shaping Filters for Generating Nonstationary Random Outputs. (ISA paper) *M. M. Sondhi, T. J. Higgins*, University of Wisconsin.

Spectral Characterization of Control System Nonlinearities. *R. B. McGhee*, Hughes Aircraft Company.

Techniques for the Optimum Synthesis of Multipole Control Systems with Random Processes as Inputs. *C. T. Leondes, H. S. Hsieh*, University of California (Los Angeles).

Predictor Relay Servos with Random Inputs. *T. R. Benedict*, Cornell Aeronautical Laboratories.

Control Systems Components

The Control Systems Components Conference is a joint effort of AIEE, IRE, ISA, ASME, and the Society of Automotive Engineers. The tentative program for this conference follows:

Thursday, November 5

9:00 a.m. Session I—Magnetic Components—Transformers

Chairman: Reuben Lee

Proposed AIEE Standard on Wideband Transformers. (includes measurement techniques) *A. D. Hasley* (P. R. Munk, alternate).

Phase and Amplitude Variations in Wideband Transformers. *E. B. Harrison* (E. Hoskins, alternate).

High-Frequency Network Representation of Wideband Transformers. *T. R. O'Meara* (A. Trussell, alternate).

9:00 a.m. Session II—Instrumentation

Chairman: G. H. Bouman; Associate Chairman: Donald Bergman.

Dynamic Response Testing of Process Control Instrumentation. Part I—General Recommendations, RP-26.1. The session will be sponsored by ISA–RP-26 Committee. The new Recommended Practices document will be discussed by a panel group. Additional selected papers may be presented.

2:00 p.m. Session III—Magnetic Components—Amplifiers

Chairman: John Hart

Comments and panel discussion on the new proposed AIEE Magnetic Amplifier Standard. *R. M. Hubbard*, Boeing Airplane Company; *H. W. Patton*, Acromag, Inc.; *F. G. Timmel*, Westinghouse Electric Corporation; *W. R. Seegmiller*, General Electric Company; and *T. G. Wilson*, Control Division of Magnetics, Inc.

Friday, November 6

9:00 a.m. Session IV—Hydraulic Transfer Valve Session

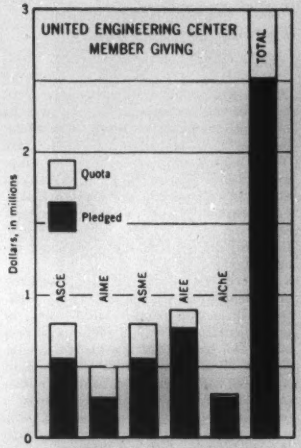
Chairman: John Gibson

Proposed AIEE Standard on Electrohydraulic Servo Valves. *John Gibson*, Purdue University; *W. J. Thayer*, Moog Servocontrols, Inc.

2:00 p.m. Session V—Electromechanical Session

Chairman: William Sollecito; Associate Chairman: Dave Bloser

Specifications on Precision Motors (ARP 497). This is a presentation of the new standard developed by Mr. Bloser's Group of SAE.



THE BAR GRAPH shows the status of member giving as of August 28, 1959. All contributions to the United Engineering Center Building Fund are tax deductible.

Wire Association Awards Given for Best 1958 Papers

H. W. Adams (AM '47, M '50) production supervisor of the Cable Division, Reynolds Metals Company, Richmond, Va., will receive the Medal Award (Nonferrous Division) from the Wire Association at its annual convention October 12-15, 1959, in Cleveland, Ohio.

Mr. Adams, who is director of electrical conductor products at Reynolds, was selected to receive the award for his paper, "Fabrication and Properties of 5005 Aluminum Alloy Cables for Overhead Conductors."

This award is one of several given by the Wire Association for the best papers presented in 1958 and published in *Wire and Wire Products*, official publication of the Wire Association.

Mr. Adams is a director of the board of the Wire Association.

Other awards will be presented at the convention, as follows:

Medal Award (Ferrous Division) to D. K. White, foreman, annealing, John A. Roebling's Sons Corporation, for his paper, "Continuous Patenting, Cleaning, and Coating of Steel Rod."

Certificate of Honorable Mention (Ferrous Division) to Dr. Ing. Hans Krautmacher, chief of Experimental Station, Westfaelische Union, Hamm, Germany, for his paper, "Recent Experiences in Shot Blasting Practice."

Certificate of Honorable Mention (Nonferrous Division) to J. F. Stoltz, chief engineer, rod and wire mill, Western Electric Company, for his paper, "Drawing and Insulating Wire in One Tandem Operation."

Papers and articles are judged by an Award Committee, consisting of 12 members, on the basis of the Oxford System.

Solid-State Devices Featured for ISA Symposium

A series of 16 papers evaluating "Solid Facts About Solid State" from the viewpoint of the instrument engineer will be presented at a 2-day symposium in Philadelphia, Pa., on November 23–24, 1959. To be held in conjunction with an equipment display at the Benjamin Franklin Hotel, the symposium is sponsored by the Philadelphia Section of the Instrument Society of America (ISA), with AIEE and the Institute of Radio Engineers as cooperating societies.

Subjects and speakers have been selected for their ability to draw a broad, well-rounded picture of this latest trend in instrumentation. The Philadelphia Section of the ISA has extended a blanket invitation to all business groups interested in this field. The program which follows indicates the scope of interests covered.

Tentative Technical Program

Monday, November 23

9:30 a.m. Session I—Fundamentals of Solid-State Techniques

Semiconductor Devices. *Charles Simmons*, Lansdale Tube Division, Philco Corporation.

Magnetic Amplifiers. *Doctor H. F. Storm*, General Electric Company.

Solid-State Transducers. *H. Henkles*, Westinghouse Electric Corporation.

Zener Diode Reference Standards. *J. T. Nichols*, Daystrom-Weston Industrial Division.

2:00 p.m. Session II—Solid-State Circuits and Devices

Transistorized Low Level Amplifiers. *J. A. Watson*, Texas Instruments Company.

Low Level Magnetic Amplifiers. *W. A. Geyger*, Naval Ordnance Laboratory.

Thermistors in Instrumentation. *M. L. Miller*, Victory Engineering Company.

Semiconductor Strain Gages. *F. T. Geyling*, Bell Laboratories.

9:00 a.m. Session III—Solid-State Instruments and Systems

Semiconductor Computer Modules for Nuclear Safety Circuits. *T. Patchall*, Minneapolis-Honeywell.

Magnetic Cores and Transistors in Data Transmission. *I. L. Auerbach*, Auerbach Electronics Corporation.

Static Control Element Applications. *F. Ennis*, Briggs Associates.

Low Level Signal Switching. *J. A. Riedel*, Teledynamics, Inc.

2:00 p.m. Session IV—Systems, Reliability, and Computer Control

Solid-State Computer Control—Case History. *Joseph Reins*, Louisiana Power and Light.

Core–Transistor Computer Control Reliability. *Ralph Bengheit*, Information Systems, Inc.

Automatic Solid-State Industrial Control Application. *C. B. Anderman*, Armstrong Cork Company.

Reliability of Solid-State Components. *Leo Landrey*, Burroughs Corporation.

The series of papers will be available at the symposium. A banquet will be held Monday, November 23 at 6:00 p.m., with Charles De Carlo, assistant general manager, Data Systems Division, International Business Machines Corporation, as guest speaker.

Further information is available from F. G. Daveler, symposium chairman, International Resistance Company, 401 North Broad St., Philadelphia 8, Pa.

Sarnoff Gold Medal Awarded to Dr. W. R. G. Baker

Dr. W. R. G. Baker (AM '19, F '47), president, Syracuse University Research Corporation, has been named recipient of the David Sarnoff Gold Medal Award of the Society of Motion Picture and Television Engineers (SMPTE) for meritorious achievement in television engineering.

In making the award, the society cited Dr. Baker's "long career in electronics, which actually started before the field was recognized as electronics," and praised his achievements as chairman of the National Television System Committee which worked out the technical standards which have since been accepted by the Federal Communications Commission as the basis of the commercial television system of the United States.

Dr. Baker recently retired from the General Electric Company where he had been a vice-president in charge of all electronic activities and a consultant to the company's executive office.

He is a member of the National Research Council, the Army Scientific Advisory Panel, the Electronics Division, American Ordnance Association, and civilian chairman of the Signal Corps Research and Development Advisory Council. Also, he is chairman of the National Television Stereophonic Committee's Administrative Committee.

He is a fellow of the Standards Engineering Society and the Institute of Radio Engineers (IRE). He is past president and director of the Electronic Industries Association, director emeritus of the Electronic Industries Association engineering department, and a member of numerous other professional organizations.

Dr. Baker is a graduate of Union College. He holds three honorary doctorate degrees, from Union College, Syracuse University, and Polytechnic Institute of Brooklyn.

During World War II, he was cited by both the Army and Navy for his contributions to the development, design, and production of complex radar and radio equipment. In 1953, he received the Army's Medal of Freedom, and, in the same year, the Medal of Honor of the Radio-Electronics-Television Manufacturers' Association. In 1952, he was awarded the IRE Medal of Honor.

Presentation of the David Sarnoff Gold Medal will take place during the 86th semiannual convention of SMPTE, October 5-9, at the Statler Hilton Hotel in New York City.

New London Subsection Studies Student Possibilities

Encouraging qualified secondary school students to pursue a technical field in further education has been the subject of activity by the New London (Conn.) Subsection of AIEE.

An Educational Committee was appointed in September 1958, with Lt. Cmdr. E. P. Rivard (AM '45) as chairman, to investigate the area of interest and to make recommendations for action.

The program began with a talk by Robert Gaines, superintendent of schools in the Town of Groton, who spoke of the state law requirements for teachers in private schools, and pointed out that Eastern Connecticut was rich in qualified technical and scientific personnel.

The committee investigated pertinent literature on the subject, and found that various papers presented in the *Journal* of the American Society for Engineering Education showed an awareness of the need for quality in freshman engineering. The paramount reason for the low number of college entrants and graduates was given as lack of adequate guidance and motivation at the secondary school level.

In material published by the American Council on Education, not utilizing more women in technical fields was called a national waste of brainpower resources.

A pilot project for the beginning of the year 1959 was recommended by the committee, which suggested that the Subsection arrange plant tours locally with one high school group, preferably a "fast-track" group. In order to attain "person-to-person" contact between the student and engineer or scientist, the number of students making the tour was limited. Students of grades 12 and 11 were favored because younger persons lacked the background subjects needed.

Arrangements were made with Peter Nikula, principal of Robert Fitch High School in Groton, who suggested that the Advanced College Preparatory Course seniors make the first tours.

These were held at the Navy Underwater Sound Laboratory, with J. A. Wheeler as sponsor, and the Electric Boat Division of General Dynamics, with William Foye as sponsor, in January and February, respectively, this year. Ten to 15 students, boys and girls, participated in these tours. Trip insurance was arranged by the school. The importance of mathematics was underscored in each tour as fundamental to technology. No attempt was made to proselytize for any particular field during the tours. A deliberate effort was made to emphasize the useful, interesting, and rewarding nature of the "technical way of life." In presentation of the tour material, it was necessary to avoid use of trade names, technical argot, and sophisticated concepts. However, the high school people were able to follow explanations put forth simply and fundamentally. The concensus was that the "pitch" should be one that they could "reach" for.

A third tour was arranged for juniors of the same course. During March, 17 of the group toured the Charles Pfizer plant, sponsored by Kenneth Chapman. Mr. Chapman graduated from Fitch in 1944.

The juniors, like the seniors, were a receptive and alert group. None of the juniors had colleges picked at this time, other than tentatively. The seniors, however, were in general committed to their post-high school work when they took the tours.

A tour was arranged for juniors during April to the Robert Gair Division of Continental Can Company, with Dr. Verseput and G. M. James as sponsors. Another tour for juniors was held at the Marine Laboratory of Maxim Evaporator Division at Millstone Point, with Bruce Watson as sponsor.

Following the tours, questionnaires were given to groups. The young persons commented in an articulate and intelligent manner and offered suggestions for the improvement of the program. Close communication was maintained with the principal during this study in a search for improvement. The importance of close communication with the school was emphasized. Various school teachers and officials cited the advantage of having an outside source foster goals common to those of the high school courses.

The project was undertaken by the Subsection on a pilot basis only to learn the problems and advantages of this type of program. On an area-wide extension of the program, the committee suggested that some "intersociety organization" made up of local engineering groups might coordinate the program on a multischool basis.

It was recommended by the Educational Committee that the tours be a continued activity of the Subsection, in co-operation with other interested groups.

Technical Program Given for Machine Tool Conference

The 11th Annual AIEE Machine Tool Conference will be held October 19-21, 1959, in Cleveland, Ohio, at the Sheraton-Cleveland Hotel.

Registration will begin Monday, October 19, at 8:00 a.m. At 7:30 p.m., a banquet will be held, with Fred Smith as the speaker on the subject. "Little Secrets in Big Successes." On Tuesday, October 20, 1959, Darrel Romick, Goodyear Aircraft, will speak at the luncheon, beginning at 12:30 p.m., on the topic, "Astronautics."

The tentative technical program for the conference follows:

Monday, October 19, 1959

9:00 a.m. Plant Visits

J & L Steel Corporation or TAPCO.

2:00 p.m. Afternoon Session

Welcome: E. J. Loeffler

Keynote Talk: W. K. Bailey, president, Warner & Swasey Company.

Applications of the Process of Roll Flowing. *W. H. Busch*, Lodge & Shipley Machine Tool Company.

New Processes for Tape Preparation for Numerically Controlled Machine Tools. *Samuel Matsa*, International Business Machines Corporation.

NMTBA Electrical Standards Committee report.

Tuesday, October 20

9:00 a.m. Morning Session

Printed Circuit Motors. *R. P. Burr*, Printed Motors, Inc.

Rectiflow Machine Tool Applications. *E. G. Watson*, Westinghouse Electric Corporation.

Machine Tool Applications of Static Adjustable Speed Drives. *W. K. Boice*, General Electric Company.

New Electric Products for Machine Tools. Seven electrical manufacturers.

2:00 p.m. Afternoon Session

Position and Rate Control of Infeed on a Centerless Grinder. *P. Ohringer*, Cutler-Hammer, Inc.

Numerically Controlled Template Grinding and Turning Machine. *G. D. Stewart*, Ex-Cell-O Corporation.

Modern Trends in A-C Motor Design and Application. *R. J. Dineen*, Allis-Chalmers.

Panel (subject to be announced).

Wednesday October 21

9:00 a.m. Morning Session

Benefits of Statistical Specifications and Acceptance Testing. *H. France*, Pratt and Whitney Company.

New Electric Products for Machine Tools. Four electrical manufacturers.

Operating Experiences with Cybernetic Control on Automated Machine Tools. *K. Sheffer*, Ford Motor Company.

A 10-Year Look into the Future for Machining. *M. E. Merchant*, Cincinnati Milling Machine Company.

1:00 p.m. Field Trips

Lucas, National Acme, Foot Burt Company, and Airport facilities.

H. C. Harrison Awarded Franklin Institute Medal

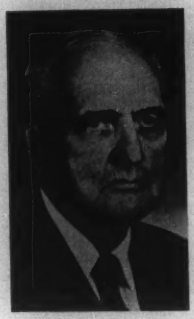
H. C. Harrison (AM '19, Member for Life) of Port Washington, N. Y., the electrical engineer whose "matched impedance" principle in electromechanics revolutionized high fidelity phonograph and communication equipment, will receive an Elliott Cresson Medal from the Franklin Institute, Philadelphia, Pa.

Mr. Harrison, former member of Bell Telephone Laboratories, will be awarded the medal at formal institute ceremonies, Wednesday, October 21.

The medal citation to Mr. Harrison reads: "In consideration of the discovery and application of the conception of wave energy flow through electrical, mechanical, and acoustic devices, resulting in the matched impedance principle, as well as a lifetime of prolific invention in telephony and allied fields."

Mr. Harrison's inventions improved sound recording and transmission instruments, such as telephone transmitters, receivers, microphones, loudspeakers, horns, records, recorders, and reproducers; acoustical measurement devices; and switching apparatus for telephone systems, including wire spring devices such as relays, switches and keys, glass enclosed switches and relays, and vibrating reed signaling devices. The matched impedance principle was applied by Mr. Harrison to many mechanical and electromechanical devices and systems.

The Cresson Medal, which Mr. Harrison will receive, was founded in 1848 by Elliott Cresson of Philadelphia. It is awarded annually by the institute to one or more persons for discovery or original research adding to the sum of human knowledge.



H. C. Harrison

The Franklin Institute is a 135-year-old scientific and educational organization composed of a science museum with educational services, planetarium, technical library, and research laboratories.

H. C. Harrison was born October 31, 1887, in Scribner, Nebr. He received his A.B. degree from Colorado College in 1910 and his B.S. degree from Massachusetts Institute of Technology (MIT) in 1913.

After spending a year at MIT as an instructor, Mr. Harrison in 1914 joined the engineering department of Western Electric Company which eventually became the Bell Telephone Laboratories. Some 38 years later, in 1952, with more than 100 patents to his credit, Mr. Harrison retired from Bell Telephone Laboratories.

Mr. Harrison was a charter member of the Acoustical Society of America.

Technical Periodicals

The technical periodicals, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis issued six times a year. Members may receive one subscription to any *one* of the technical periodicals for $2.50. The balance of the annual $5.00 subscription price will be paid by application of his annual dues for the year of the substcription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional member subscriptions will be at the rate of $5.00. Nonmembers may subscribe on an advance annual subscription basis of $8.00 each (plus 50¢ extra for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.50 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Westinghouse Executive Awarded John Fritz Medal

The John Fritz Medal Board of Award has announced that the top prize of the engineering fraternity will be awarded to G. A. Price, chairman of the board of the Westinghouse Electric Corporation.

The presentation of the gold medal awarded annually for notable scientific or industrial achievement will be made to the Westinghouse executive at the annual meeting of the American Society of Mechanical Engineers (ASME) at Atlantic City, N. J., in early December.

For the first time in the 58-year history of the award, the highest honor that engineers can bestow will go to a man with a nonengineering background for his vision and his industrial leadership in the development of atomic power.

W. F. Ryan, a past president of ASME and a member of the Fritz Medal Board of Award, announced that the honor had been voted to the industrialist by the representatives of four national engineering societies for "his inspirational leadership, industrial pioneering, and personal initiative in marshaling the creative forces of research and engineering to the cause of developing atomic power for the national defense and for the human welfare."

The four national engineering societies are AIEE, ASME, the American Society of Civil Engineers, and the American Institute of Mining, Metallurgical and Petroleum Engineers. The American Institute of Chemical Engineers will become the fifth society to administer the award, effective October 1, 1959.

"Mr. Price, at the end of World War II, saw the possibilities of harnessing the atom for practical uses and recognized the military significance of nuclear propulsion," said Mr. Ryan. "He formed an atomic power organization within his company which developed for the Atomic Energy Commission and Navy the historic

Fabian Bachrach

G. A. Price

atom plant for the *USS Nautilus*. The men he brought together have designed the nuclear propulsion plants for virtually all of the Navy's growing atomic fleet, including the Polaris-firing submarine, *USS George Washington*, and the Navy's first atomic surface ship, the *USS Long Beach*, soon to be christened.

"From the atomic submarine pioneering, Mr. Price's engineers and scientists gained the know-how which they applied in their work on the nation's first full-scale atomic-electric generating station at Shippingport, Pa., a pioneering step in the development of peacetime atomic power. Other atomic power plants now being built by Westinghouse in this country and abroad—such as the 134,000-kw Yankee Atomic Electric Company plant under construction at Rowe, Mass., and the nation's first commercial atomic electric plant to be exported, an 11,500-kw plant for Belgium—also will advance the art of atomic power and bring closer the day when the energy of the atom will, as Mr. Price has stated it, 'overcome and destroy those roots of war—poverty, insecurity, and fear.'

"This kind of industrial leadership in a new technical field abundantly merits the honor of the John Fritz Medal."

The award was established by the engineering societies in memory of John Fritz of Bethlehem, Pa., one of America's pioneers in the iron and steel industry, who received the first award in 1902. In 1905, the medal went to Lord Kelvin, famous British scientist, and, in 1906, to George Westinghouse, pioneer in establishing the alternating current system of electricity. He was the founder of the firm whose board chairman the engineers are honoring for his industrial pioneering in the development of atomic power. Other distinguished engineers and scientists who have received it include Alexander Graham Bell, Thomas A. Edison, Orville Wright, and Herbert Hoover.

A lawyer, banker, and industrialist during his career, Mr. Price is also the president of the board of trustees of the University of Pittsburgh, and has served, since 1957, as the chairman of the board of Crusade For Freedom, Inc. He is a trustee of the Carnegie Corporation of New York and the Committee for Economic Development, a member of the Business Advisory Council for the U. S. Department of Commerce, a director of the Council for Financial Aid to Education, and of a number of banks and corporations.

Mr. Price was born in Canonsburg, Pa., in 1895, the son of a roller in a steel mill. He was graduated from the University of Pittsburgh Law School in 1917, the youngest member of his class. He practiced law, became a trust officer of a bank, and served a term in the state legislature. In 1937, he was elected president of what is now the Peoples First National Bank and Trust Company, and joined Westinghouse as vice-president in 1943. He was elected president in 1946 and chairman of the board in 1955.

1959-60 AIEE Membership Directory Now Available Only to AIEE Members—Price $5

ALL AIEE officers and committee members have been sent their copies.

While the supply lasts, other interested AIEE members may secure one copy only for their own use by completing the label supplied below and sending it together with their remittance of $5 to AIEE Headquarters, 33 W. 39 St., New York 18, N.Y.

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Symposium Scheduled on High-Voltage Cable Insulation

A symposium on High-Voltage Cable Insulation, sponsored jointly by the AIEE Insulated Conductor Committee and Committee D-27 on Electrical Insulating Liquids and Gases of the American Society for Testing Materials (ASTM), will be held at 8 p.m., Wednesday, November 18, 1959, at the Governor Clinton Hotel in New York, N. Y., in conjunction with meetings of AIEE and ASTM Committee D-27.

Because of continuing industry expansion and increasing consumer loads on electric power, the power industry is constantly faced with the problem of distributing these high loads. Recent developments and improvements in electrical insulating materials have made it possible to design and use cables carry-

ing extra high voltages of 250 kv and higher. The insulation of these cables presents some challenging problems in evaluation of properties and prediction of service behavior.

The program will be as follows:

Paper for High-Voltage Cable. *W. A. Del Mar*, consulting engineer, Habirshaw Cable and Wire Division, Phelps Dodge Copper Products Corporation.

Why and How of Cable Oil Tests. *R. B. Blodgett*, research director, Okonite Company.

The Public Utility View of Cable Oils. *A. M. Gates*, senior engineer, Philadelphia Electric Company; *R. W. Gillette*, senior engineer, Consolidated Edison of New York.

While the symposium is primarily for those attending the AIEE and ASTM meetings, the public is invited. There will be no registration for the symposium. Additional information may be obtained from V. R. Mulhall, Canadian General Electric Company, Peterborough Engineering Laboratory, Peterborough, Ont., Canada.

MAECON—1959
Scheduled for November 3-5

The 11th annual Mid-America Electronics Conference (MAECON—1959) will be held in Kansas City, Mo., November 3-5. This conference is sponsored by the Kansas City Section, Institute of Radio Engineers (IRE).

A total of 45 technical papers will be presented in 15 sessions. Some sessions will be conducted by AIEE and the American Rocket Society on specialty subjects.

Dr. Ernest Weber, president of IRE and president of the Polytechnic Institute of Brooklyn, will speak at the opening session Tuesday, November 3, on "The Radio Engineer of the Future."

The technical sessions and the exhibits will be held in the spacious Municipal Auditorium located in the heart of downtown Kansas City, one block from the conference headquarters, Hotel Muehlebach.

The exhibit area of more than 100 booths will be open during the entire conference.

Additional detailed information may be obtained from: I. J. Jones, Bendix Aviation Corporation, P. O. Box 1159, Kansas City 41, Mo.

EJC Ad Series
Defines "Engineer"

"Scientists make it known, but engineers make it work!" This is the theme of a series of public service advertisements by Engineers Joint Council (EJC) now appearing in *Editor & Publisher*, business magazine for the newspaper profession. The ads are designed to create desirable understanding of engineers and engineering by printed media, radio and television, public officials, organizations and advertising agencies.

Carrying such titles as "Let's Get Clear on What Engineers Do," "Just Who's Firing Those Missiles," and "Say Engineer When You Mean Engineer!" the ads may help news writers and editors present to the public a better picture of the engineer and what he does. They also will help to clear up existing confusion between "scientists" and "engineers," terms frequently used interchangeably. (See p. 55A of this issue of *Electrical Engineering*.)

According to E. R. Needles, president of EJC, which represents 350,000 of the nation's engineers, "The engineer's hand touches every material thing used by the consumer to make his life a happier one. Our expanding economy is an engineered economy, and it is high time people realized their obligation to recognize the men and women who are making it possible.

"We, at Engineers Joint Council, hope that our advertising program on behalf of all engineers, will help to bring home to thoughtful persons, the important place of the engineer in today's world. We further hope that reporters and editors will find the information in the ads helpful to them in putting the engineer in proper reference in the news stories of our advancing technology."

EJC, in each of the ads, offers itself as a source of information and reference on the broad aspects of the engineer's responsibility, his education, and his work. EJC prepares timely and accurate reports on such matters as engineer's salaries, number of engineering graduates, number needed, and opportunities for engineering teachers.

AIEE PERSONALITIES

A. C. Bayle (AM '41) has been elected engineering vice-president of the Waltham Precision Instrument Company by its Board of Directors.

N. M. Blair (M '53) has been elected vice-president and assistant to the president of Intelex Systems, Inc., New York City, a subsidiary of International Telephone and Telegraph Corporation (ITT). He will supervise the accelerating expansion of the ITT subsidiary into the commercial and industrial automation and control fields in which Intelex designs, engineers, and installs automated banking and mail handling systems and mechanized message delivery systems for office buildings and plants.

R. S. Burnap (AM '17, F '51, Member for Life), pioneer electron tube engineer, has retired as manager of commercial engineering at the Electron Tube Division of the Radio Corporation of America (RCA). He continues to serve the division as a consultant. Mr. Burnap was associated with RCA and predecessor companies for 42 years. He has been a member of the AIEE Communication Committee (1941-44); Electronics Committee (1944-46, 1948-59); and Standards Committee (1951-57).

W. R. Carlyon (AM '50) has been appointed manager of general industrial sales, Detroit district, Allis-Chalmers Manufacturing Company. **C. R. Peter** (AM '44) and **C. R. Martin** (AM '44, M '55) have been appointed to new posts in its control department. Mr. Peter, who had been supervisory engineer for component development in the control department since 1955, is now a consultant to the chief engineer. Mr. Martin has been named supervisory engineer responsible for development activities in the control department.

Solomon Charp (AM '42, M '47) has been appointed a consulting engineer in the General Electric Company's missile and space vehicle department, Philadelphia, Pa.

J. F. Emery (M '58), superintendent of electrical operations and construction, Idaho Power Company, and **H. R. Moore** (M '58), superintendent of power, have been named vice-presidents of the company. Mr. Emery is responsible for engineering, planning, and construction of the company's operating facilities. Mr. Moore supervises power plant operations and co-ordination of Idaho Power's interconnected system with the Northwest Power Pool. He also is in charge of the utility's relations with other power pool members.

Fred Heller (AM '49, M '56) has been promoted to assistant general manager, Omaton Division of the Burndy Corporation, Norwalk, Conn., and has been added to the company's management committee.

F. R. Lack (M '37, F '48) has been elected to the board of directors of DuKane Corporation, St. Charles, Ill. He recently retired from his position as vice-president of Western Electric Company. He has served on the AIEE Communication Committee (1938-41).

T. J. Lakoski (AM '48, M '59) has been promoted to manager of quality and reliability, Owego, N. Y., facility, International Business Machines Corporation (IBM). **J. D. Fernbach** (AM '48, M '54) has been appointed manager of Owego manufacturing at the facility. **W. E. Brandt** (AM '52) has been promoted to staff engineer in the general development area of the IBM Advanced Systems Development Division, Poughkeepsie, N. Y.

M. H. Leavenworth (AM '48), formerly manager of the southwestern branch of Dow Corning Corporation, located in Dallas, Texas, is now manager of the Cleveland, Ohio, office.

H. A. Miller (AM '53) has been appointed manager of the Taylor Instrument Companies' Electronics Development Division, Rochester, N. Y. Until recently, Mr. Miller was associated with the Research Division of Raytheon Manufacturing Company and later joined Raytheon's advanced development group of the Government Equipment Division, Wayland, Mass., as manager of computer development.

Lamme Medal Nominations Must Be Submitted By December 1st

MEMBERS of the Institute again are reminded that they have an opportunity to submit nominations for the 1959 Lamme Medal. All nominations must be received not later than December 1, 1959.

Details regarding qualifications for the award were published in the June 1959 issue of *Electrical Engineering*, p. 692.

S. B. Morehouse (AM '35), former head of the electric power section, Leeds & Northrup Company, Philadelphia, Pa., has been appointed assistant to the marketing vice-president. He served on the AIEE System Engineering Committee (1947, 1949-52).

R. K. Patterson (AM '52) has been appointed manager of the Northwest District for the Daystrom-Weston Sales Division of Daystrom, Inc. He will supervise all sales and district office operations for the Sales Division in the Northwest District, which includes Washington and Oregon.

Woodman Perine (AM '35, M '47), president of Vitro Engineering Company, has been named vice-president of Vitro Corporation of America. He now directs the activities of Vitro's Technical Services and Products Group, which includes Vitro Engineering Company, New York, N. Y.; The Refinery Engineering Company, Tulsa, Okla.; Nems-Clarke Company, Silver Spring, Md.; Thieblot Aircraft Company, Martinsburg, W. Va.; and Vitro Laboratories, Silver Spring, Md.

G. A. Price (AM '47), chairman of the board, Westinghouse Electric Corporation, Pittsburgh, Pa., received the honorary degree of doctor of laws from Lehigh University, Bethlehem, Pa., at its 91st commencement exercises. Mr. Price was cited for his contributions to higher education.

J. G. Robinson (AM '44) has been appointed technical assistant to the president and procurement director, McLean Engineering Laboratories, Inc., of Princeton, N. J.

S. E. Schultz (AM '25, F '47) has been elected a director of H. Zinder & Associates, Inc., consultants. He is a partner and manager of the H. Zinder & Associates office in Seattle, Wash. He has served on the AIEE Power Transmission and Distribution Committee (1944-46) and Transformer Committee (1949-52).

J. E. Smith (AM '39), vice-president and director of the Datamatic Division of Minneapolis-Honeywell Regulator Company, has been awarded an honorary doctor of science degree from his alma mater, Jamestown College in North Dakota. He has served on the AIEE Communication Committee (1947-49).

E. H. Snyder (AM '27, M '33, F '49), vice-president in charge of electric operations of the Public Service Electric & Gas Company, Newark, N. J., was re-elected president of the Lehigh University Alumni Association June 6 at the group's annual breakfast meeting in the University Center. Mr. Snyder, who is a member of the class of 1923, was also elected to a 1-year term as an alumnus trustee of the university.

R. C. Sogge (AM '26, F '53), president of the U. S. National Committee of the International Electrotechnical Commission, received the honorary degree of doctor of engineering from Ohio Northern University, Ada, Ohio, June 14 at graduation ceremonies. The honor was extended to Dr. Sogge, an alumnus of Ohio Northern, for his extensive work on technical and industry standards, both national and international. He has served on the AIEE Standards (1947-49), Safety (1952-54), and Technical Operations (1954-56) Committees.

C. K. Strobel (AM '24, M '30, Member for Life), engineer, consulting department on semiconductor devices, Westinghouse Research Laboratories, Pittsburgh, Pa., was honored by the American Society for Testing Materials at its 62nd annual meeting June 23 in Atlantic City, N. J. The award was made in recognition of intensive and constructive efforts in technical activities, especially in Committee B-4 on Metallic Materials for Electrical Heating, Resistance and Contacts, particularly notable in the work on contact materials.

Tullio Tognola (AM '51) has been named assistant director of engineering, Scintilla Division, Bendix Aviation Corporation. Mr. Tognola, who has been chief research engineer since 1939, will continue to direct research and development activities on reciprocating, jet, and missiles ignition systems, as well as various types of ignition, vibration, and jet engine analyzers. In his new position he also will direct and coordinate activities of Scintilla's other engineering laboratories.

J. H. Vogelman (M '49) has been appointed director of research and development, Military-Industrial Division, Dynamic Electronics-New York, Inc., Richmond Hill, N. Y. Prior to his joining Dynamic, he was technical director of the Directorate of Communications, U. S. Air Force's Rome Air Development Center. He has served on the AIEE Communication Theory Committee (1957-58).

J. B. Ward (AM '40, M '49) has been named to direct the work of the new research department organized by the Pacific Power & Light Company (PP&L) to manage technical and scientific investigations. Mr. Ward has been supervising use of PP&L's electronic computer for engineering analyses. He has served on the AIEE System Engineering Committee (1950-59).

M. N. Waterman (AM '49), manager of commercial engineering, Westinghouse Electric Corporation Lamp Division, represented the American lamp industry at the International Electrotechnical Commission meeting during July 1959 in Madrid, Spain. He has served on the AIEE Production and Application of Light Committee (1950-55).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Gunnar Wennerberg (AM '55) has been named to head product development in the Lockheed Electronics and Avionics Division, Los Angeles, Calif.

H. B. Whittaker (AM '37, M '51) has been promoted to vice-president and chief engineer of Underwriters' Laboratories, Inc., with headquarters in New York, N. Y.. He has served on the AIEE Safety Committee (1951-59, chairman 1955-57).

B. M. Wolfframm (AM '53) has been named vice-president and technical advisor, Magnetic Research Corporation (MRC), Hawthorne, Calif. **H. F. Eckerle, Jr.** (AM '48) is now engineering manager at MRC. He has served on the Magnetic Amplifiers Committee (1956-59).

Makoto Yoshida (AM '56) has joined the technical staff of the Ramo-Wooldridge Division, Thompson Ramo Wooldridge Inc.

OBITUARIES

Vaughan R. Bacon (AM '19), retired senior engineer of the American Electric Power Service Corporation (AEP), died recently at his home in Orange, N. J. He was 70 years old. Born in Beatrice, Nebr., Mr. Bacon was a graduate of the University of Wisconsin with a B.S. degree. He also attended the Massachusetts Institute of Technology. In World War I, he was a second lieutenant in the Army Air Corps. Following the war and prior to his employment by the AEP in 1935, he worked for Ford, Bacon & Davis Inc., engineers, in charge of a project in Louisiana. About 1925, he joined the United Gas & Improvement Company in Philadelphia, Pa., where he took charge of electrical projects. He was retired 5 years ago from AEP, where he worked 20 years as an electrical engineer in the Electrical Division. In addition to handling numerous station projects, Mr. Bacon was responsible for numerous fire fighting applications in use in the AEP system.

Frederick J. Given (AM '28, M '48), administration vice-president, Sandia Corporation, died recently. He was born November 7, 1896, in Woburn, Mass. Mr. Given was employed by Western Electric Com-

pany in 1919-25, when he supervised a group of engineers who were developing coils and capacitors for telephone apparatus. In 1925-52, he held various supervisory positions at Bell Telephone Laboratories, where he was assistant director of apparatus development before he joined Sandia. At Sandia, he was director of apparatus engineering until, in 1956, he was appointed vice-president in charge of research and development technical services. He was named administration vice-president in January 1959. A graduate of the Massachusetts Institute of Technology (MIT) and Harvard University with B.S. degrees, Mr. Given was named "Mr. MIT" of New Mexico in 1958. He was chairman of the MIT Regional Conference held in Northern New Mexico in February 1959, whose subject was "The Role of the Southwest in Engineering." He served on the board of directors of the Northern New Mexico Section, AIEE, and as chairman of the U. S. Mica Mission to the United Kingdom in 1943. Mr. Given was a consultant for the War Production Board from 1943-45. He was chairman of the Panel on Components, Research and Development Board, Department of Defense (DOD), in 1947-53, and was a member of the Advisory Group on Reliability of Electronic Equipment, DOD, in 1951-54. Mr. Given was a licensed professional engineer in New York and New Mexico.

Charles E. Ide (AM '16, F '51), president of the Toledo Edison Company and former Cities Service Company executive, died recently at the age of 67. A graduate of engineering from Iowa State University, Mr. Ide joined Cities Service in 1914. He later went to Bristol, Tenn., as vice-president and general manager of a group of utilities that were merged to form the East Tennessee Light and Power Company, of which he became president in 1940. He came to Toledo Edison, Toledo, Ohio, in 1945, after sale of the Bristol property to the Tennessee Valley Authority. He was a director of the Power Reactor Development Company, the Edison Electric Institute, and of the Ohio Electric Utility Institute.

Thomas Erb Mansfield (M '37), assistant chief engineer of Central Power and Light Company, died recently. A native of Hillsboro, Texas, where he was born January 17, 1901, he was a registered professional engineer in both Texas and Oklahoma. He was graduated from the Texas University in 1923 with a B.S. degree in electrical engineering. He entered the Central Electric test course and remained until 1926, when he returned to Texas where he worked for Dallas Power and Light Company. In July 1929, he joined the Oklahoma Power and Water Company, remaining until February 1947 when he transferred to Central Power and Light Company. At Oklahoma Power and Water Company, Mr. Mansfield was a vice-president and director. At the time of his death, he was serving as state director of the Texas Society of Professional Engineers.

Vincent R. Murphy, Jr., (AM '52), an executive of the Reliance Electric & Engineering Company, died recently. He was born April 14, 1926, in Manila, Phillippine Islands, where his father, retired Vice-Admiral V. R. Murphy, was stationed. He was graduated from the Massachusetts Institute of Technology (MIT) with B.S. and M.S. degrees, and was a member there of Tau Beta Pi and Eta Kappa Nu. He joined Reliance in 1950, and soon became an application engineer. Subsequently, he had posts in the marketing organization. Later, he was appointed manager of the controls department. At his death, he was manager of the special products department. He was a member of the MIT Club of Cleveland, Ohio. During World War II, he served in the U. S. Navy for 2 years.

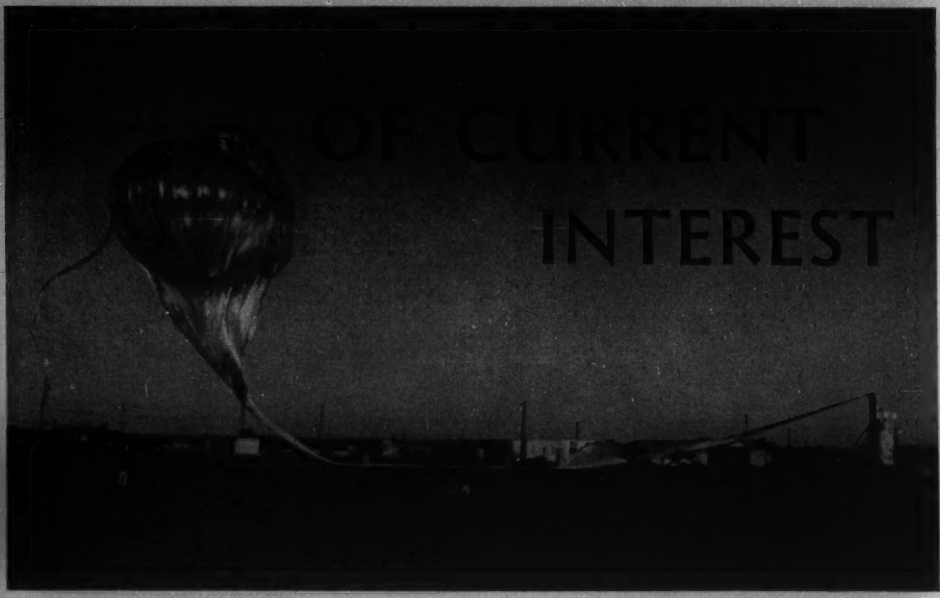
John Ellis Ostline (M '27, F '46), who retired in January 1958 as an engineer for the General Telephone Laboratories, died recently at the age of 73. Born August 25, 1885, in Sweden, he studied at Technical College, Sweden. He came to the United States in 1905 and started his telephone career as a combination lineman, installer, and maintenance man for an independent company in Minnesota. After working in several engineering positions at independent and Bell Telephone exchanges in the Northwest, he was assistant chief traffic engineer of Tri-State Telephone Company, St. Paul, Minn., and, in 1922, he joined Automatic Electric Company. In 1923, the company sent him to London, England, where he played a vital role in converting the world's largest city to dial. That year, also, Mr. Ostline began work on the foremost achievement of his career, the development of automatic toll ticketing equipment. This and following contributions led to the commercial system known today as SATT. In 1947, Mr. Ostline was presented with the Talbot G. Martin award, Automatic Electric's highest honor, for outstanding achievement in the art of communications. He was a chartered electrical engineer in Great Britain, and a member of the Institution of Electrical Engineers in England.

B. Parks Rucker (AM '03, F '13, Member for Life), consulting and construction engineer in Charlotte, N. C., died recently. He was born February 20, 1876, in Amherst County, Va., and studied mechanical and electrical engineering at Drexel Institute. He was a member of the American Society of Mechanical Engineers and the Engineering Association of the South. In 1900-01, he worked for Rossiter and MacGovern Company, and, in 1901, as electrical test expert in the New York Navy Yard. That year he sold a patent on electrical circuit breakers to the General Incandescent Arc Light Company, and he became an electrical draftsman there to develop the invention for market. In 1902, he became a designing draftsman on oil circuit breakers and similar detail apparatus for the Westinghouse Electric and Manufacturing Company. Two years later, he was engineer in charge of circuit breakers, switches, relays, and other detail apparatus. He was transferred, in 1905, to the Transformer Division, where he designed shunt and series transformers, and, in 1906, he was transferred to the construction department, Great Falls, S. C., where he was assistant in charge of installation of electrical machinery in the Southern Power Company power plant. Mr. Rucker became a consulting and construction engineer in 1907.

William A. Stein (AM '44, M '51), a professor of electrical engineering at the U. S. Naval Postgraduate School, Monterey, Calif., died recently at the age of 37. He was born May 5, 1922, in St. Louis, Mo., and received B.S., M.S., and D.Sc. degrees from Washington University. He was a member of the faculty of Washington University prior to joining the faculty of the U. S. Naval Postgraduate School in June 1951 as a professor. His special field was feed-back control systems. He was a member of Sigma Xi and Tau Beta Pi. In 1943-45, he was research engineer for Alco Valve Company, investigating magnetic properties of stainless steel.

Bertram Orlando Vannort (M '40), president of B. O. Vannort Engineers, Inc., Charlotte, N. C., died recently. Born July 2, 1900, in Port Deposit, Md., he was educated at the Tome School, Port Deposit, and at the University of Michigan, where he received a B.S. degree in 1928. Before coming to Charlotte, he was employed by Gibbs and Hill of New York and various engineering concerns. In 1939, he became a consulting engineer in Charlotte, specializing in rural electric projects. When war broke out, he returned to Gibbs and Hill as vice-president. In 1945, he came back to re-establish his practice. He built a large organization, working on projects for electric and telephone utilities and the U. S. Defense Department, in addition to school and industrial buildings. Mr. Vannort was a member of Tau Beta Pi, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Consulting Engineers, and the Charlotte Engineers Club, Charlotte, N. C.

James Robert Werth (M '45), who taught at the Virginia Polytechnic Institute (VPI) until his retirement, died recently in Richmond, Va. Born January 3, 1884, in Richmond, Va., he graduated from the VPI in 1903 with a B.S. degree in electrical engineering. Upon graduation, he was employed by General Electric Company in Schenectady, N. Y., where he served as a sales engineer, until he entered the U. S. Army in April 1917. He was in charge of construction of electrical power plants and TNT plants in Saltville, Tenn. On his retirement from the Army in 1920, he went to West Penn Power Company in Pittsburgh, Pa., where he served as commercial service manager. His next position was for the H. M. Byllesby Company as company manager and power sales manager in Poteau, Okla., and Fort Smith, Ark. Returning to the East, Major Werth was manager of the Gas and Electric Company in Lynchburg, Va., and, later, in charge of new business for power sales for the Florida Power and Light Company, Miami, Fla. He next went to Brazil as commercial manager for the State of Sao Paulo. Returning from Brazil, he was with the Rural Electrification Administration, Washington, D. C., and then taught at VPI. Major Werth was a life member of the Institute of Military Engineers.



INFLATION of the balloon for STRATOSCOPE I, *a balloon-borne 12-inch solar telescope project sponsored by the National Science Foundation and the Office of Naval Research.*

Television Joins Telescope in Stratoscope I Balloon Flights

TELEVISION has joined a telescope in balloon flights 80,000 feet above the earth, as an important new tool for astronomers working on a research project supported jointly by the National Science Foundation and the Office of Naval Research.

The 12-inch STRATOSCOPE I solar telescope made a new series of flights in the summer of 1959. It was equipped with a closed-circuit television link, with control of the telescope at the ground, for remote-control pointing of the telescope at the sun. The telescope-camera photographed an area with a width $\frac{1}{10}$ the diameter of the sun. In addition, the television camera was linked optically to a motion-picture camera to obtain a continuous record of images that appear in the telescope reflector. The kinescope images taken on the ground covered $\frac{1}{5}$ the area shown in the telescope, or $\frac{1}{25}$ the diameter of the sun.

Director of the project was Dr. Martin Schwarzschild of Princeton University, who directed earlier STRATOSCOPE I flights in 1957.

Purpose of sending the telescope up in a balloon is to get it above the earth's atmosphere, which obscures clear visibility of celestial objects. In particular, to get high resolution photographs of the sky it is necessary to send telescopes above the tropopause, a turbulent layer at about 40,000 feet that is a major area of interference. Such atmospheric interference causes fluctuations in refraction of light from the sky, resulting in "twinkling" of stars and other manifestations of poor visibility. For example, under the best atmospheric conditions the 200-inch telescope at Mt. Palomar can rarely distinguish between two points on the moon's surface less than 1,800 feet apart, while it could distinguish between points only 120 feet apart if it did not have to "look" through the earth's atmosphere.

The remote-control guidance system, coupled with the television by which ground observers can watch the area being observed by the telescope, made it possible to point the instrument at a region of particular interest, such as a sun spot, and follow with high resolution any changes in time.

The 1957 flights of STRATOSCOPE I, made under the sponsorship of the Office of Naval Research and with assistance from the Air Force Cambridge Research Center, resulted in the first successful attempts at high-altitude astronomy. The special sun telescope-camera, which with considerable modification was used this summer, made two unmanned balloon flights and took photographs of the sun's surface that were unprecedented in clarity and detail. They showed for the first time the detailed polygonal structure of the convective currents ("granulations") that bring much of the internal solar energy to the sun's surface.

The STRATOSCOPE I solar telescope-camera was designed and built by the Perkin-Elmer Corporation, Norwalk, Conn. This firm is now working on the design and construction of the STRATOSCOPE II instrument. Television equipment for STRATOSCOPE I, including a specially designed slow scanning airborne camera, transmitter, and ground monitoring system, was provided by the David Sarnoff Research Center of Radio Corporation of America (RCA), Princeton, N. J. General Mills, Inc., Minneapolis, was contractor for the balloon, launching, suspension, and retrieval. The radio-command and telemetry equipment was built by Data Control Systems, Danbury, Conn.

Television System

Designed to operate at ranges of up to 150 miles, the new RCA television system includes airborne camera, transmitter, and antenna units, and a ground-based assembly comprising a receiver and three special monitors. When the telescope is aloft, the airborne system transmits to the ground once each second a picture of what the telescope sees, providing a visual guide for the ground observers to aim and focus the instrument by means of a separate radio control system. The frame rate of one picture per second is in contrast to the 30 pictures per second of standard broadcast television. The slow scan rate in the television system in the STRATOSCOPE I provides ground viewers

with all of the information that is required, and at the same time permits the use of simplified low-power airborne equipment operating within a narrow frequency band.

The camera and transmitter together require only 76 watts of power, and the transmission requires a bandwidth of only 200 kc, one-twentieth that of the 4-mc bandwidth needed for broadcast television. The complete system was developed by an RCA Laboratories research group supervised by L. E. Flory consisting of W. S. Pike, J. M. Morgan, G. W. Gray, and L. A. Boyer, working under the direction of Dr. V. K. Zworykin, honorary vice-president of RCA, at the David Sarnoff Research Center, Princeton, N.J.

The Airborne Camera

Employing a 1-inch Vidicon pickup tube and transistorized circuits, the television-camera is housed in a pressurized case for high-altitude operation. The camera weighs slightly more than 12 pounds, measures 8 by 6 by 5 inches, and consumes 16 watts of power. The circuitry, comprising 27 transistors and one subminiature tube in addition to the Vidicon pickup tube, is arranged on an assembly of printed boards for simplicity and ruggedness.

The camera is mounted on the telescope structure beside a motion-picture camera which supplies a permanent photographic record of the observations. The two cameras are linked optically by a mirror system. During the flight, a shutter arrangement causes the telescope image to be reflected during 1/1000 of a second once each second to the television camera. The televised image is transmitted to the ground during the remainder of the second, completing the job just in time for the next brief exposure. In this manner, the ground observers receive on the television screens a series of images identical to those being recorded by the motion-picture camera from the telescope, giving them a visual check for use in adjusting the telescope's aim and focus by means of the radio control system.

Airborne Transmitter

The images from the camera are transmitted to the ground through a 30-pound FM transmitter contained in a pressurized case and attached to the framework of the telescope mounting along with the radio control system and the battery power supplies. The specially designed transmitter consumes 50 watts and operates at a frequency of 227.5 mc with a power output of 10 watts, sufficient for line-of-sight transmission over distances of up to 150 miles.

Antenna Structure

A single antenna, fed through a diplexing system, is used both for the television transmission and for the transmission of radio telemetering signals from the balloon to the ground to give information regarding the operation of the stabilizing equipment as well as the television camera. Designed by an RCA Laboratories antenna research team under O. M. Woodward, the antenna assembly includes four 35-inch poles mounted in a fashion resembling the legs of a stool and extending downward from a structure suspended below the telescope assembly. The antenna is mounted in shock-resistant foam plastic below which the four poles project approximately 10 inches. Another antenna about 6 feet long extends from the center of the assembly and is used for the reception of command signals for control of the telescope from the ground.

Monitors

The specially designed monitors for the ground observers present the transmitted images on 7-inch screens employing a long-persistence orange phosphor which retains the image in bright form during the slow scanning process. With the exception of the image tubes, the monitors are completely transistorized and employ printed circuits. Two of the three monitors are used for direct viewing, while the third is employed for photographic recording as a later check against the motion picture film record compiled by the film camera mounted on the telescope.

Solar Telescope-Camera

The Perkin-Elmer solar telescope is a 12-inch aperture system especially designed to operate with high performance at altitudes 80,000 feet and above. It has an effective focal length of 2,400 inches, and an f/8 paraboloid quartz primary mirror whose surface does not depart more than one millionth of an inch from a parabolic curve.

The primary information to be gained from the STRATOSCOPE I flights will be obtained with a special 35-mm camera incorporated into the telescope design. A frame size 1 by 1½ inches is exposed, roughly equivalent to ½% of the sun's area, or 50,000 by 75,000 miles. Exposure time is 1/1000 of a second, and the camera carries sufficient film to take 8,000 exposures.

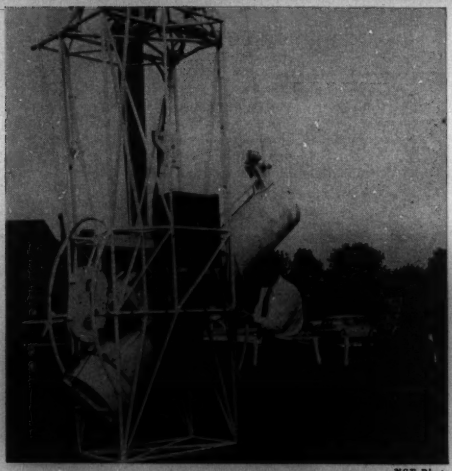
How System Operates

A part of the solar image produced by the primary mirror falls on a small, 1- by 1½-mm speculum metal mirror embedded in a sheet of copper. The copper conducts away the heat of the image. The small mirror deflects the small portion of the image to be photographed to a 25-power transfer lens and then to the camera at the back of the telescope. A beam-splitter just in front of the film location diverts 80% of the energy to the film, and 20% of it to the Vidicon television camera.

The small transfer lens can be traversed axially upon command from the ground so that proper focus is obtained. The focal length of the telescope is subject to change because of the hot solar image on the primary. In the 1957 flights, when no ground control was used, the transfer lens was traversed automatically, but this meant that only one in every 20 exposures could be in perfect focus.

Pointing of the telescope is achieved through the use of sensitive photodiode "eyes." Signals from the "eyes" go to an amplifier and through a power supply to drive motors which move the telescope in azimuth and elevation. The "eyes" are

A SPECIAL TELEVISION SYSTEM to permit astronomers on the ground to aim and focus a telescope suspended from a balloon 15 miles above the earth was developed by RCA Laboratories for Princeton University in an experiment sponsored by the National Science Foundation and the Office of Naval Research. Here L. E. Flory, of the RCA Laboratories technical staff at the David Sarnoff Research Center, Princeton, examines one of the circuits of the miniature camera which was mounted on the telescope structure. Also shown are the camera *(rear)* and its pressurized case *(right)*. The system also includes a special airborne transmitter, and three monitors and a receiver for viewing on the ground. In operation, the system will transmit one picture per second from balloon to ground over a range of up to 150 miles.



NSF Photo

BEFORE THE FLIGHT *(above)*, telescope equipment is checked and balloon inflated for project Stratoscope I. *Left:* Dr. Martin Schwarzschild of Princeton University, scientific director of the project, inspects equipment. Black box above Dr. Schwarzschild houses telemetry and remote-control command mechanism, with television transmitting equipment on frame below it. Telescope-camera and magazine are also visible. *Bottom, left:* Stratoscope I photo of sun spot. The high definition of this photograph makes it possible to study the interrelations between the magnetic field of the sun spot and the surrounding area. A sun spot consists of an umbra (the center—dark in photo) and penumbra (lighter), and is known to contain a strong magnetic field which extends beyond the limits of the spot itself. In the magnetic field outside the sun spot, the solar granulations appear hazy and with little contrast. Outside the magnetic field they appear in their usual contrast and polygonal shape.

mounted so that they can be displaced upon ground command to look at selected parts of the solar disc. The servo drive system for guidance of the telescope also has been replaced for the new flights to improve stability by doing away with some of the rotating equipment.

Telemetry-Command System

Data-Control Systems, Inc., Danbury, Conn., supplied a multichannel telemetry-command system to Princeton University for use in the STRATOSCOPE I project.

The telemetry-command system provides up to 36 channels of information, radioed to the earth from the balloon, and 6 command signals sent from the earth to the balloon. Included in the airborne package was the new transistorized voltage-controlled oscillator, developed by the company as a modular component for use in missiles and satellites under extremely stringent environmental conditions.

Stratoscope I Balloon

A General Mills balloon—139 feet in diameter and 200 feet in length, with a capacity of one million cubic feet—was used to lift the STRATOSCOPE I equipment.

The balloon of 2 mil polyethylene weighs approximately 675 pounds, the payload approximately 1,700 pounds, and the parachute (to carry the equipment to the ground) another 80 pounds, which made the gross weight of the entire flight train about 2,455 pounds. With the parachute extending 90 feet and the remote-control mechanism another 16 feet, the length of the entire flight train was approximately 300 feet.

The balloon was launched by the dynamic method, a technique that involves use of a fixed launching platform for the balloon and a truck-mounted mobile launching platform for the payload.

The balloon was designed to be automatically separated from the load by an electromechanical timing device after 3 hours at ceiling. The 70-foot diameter parachute then opens immediately and lowers the load to earth. It takes about 25 minutes for the parachute and payload to reach the earth.

Upon being released from the load, the balloon, which is expendable and had served its purpose, ascends until it bursts.

Recovery crews were on hand to track the balloon during its flight and recover the equipment after landing. The shock of parachute landing is absorbed by a General Mills-designed honeycomb pad 24 inches thick. Both aircraft and ground vehicles are used in the tracking operation.

A E E I
75th Anniversary

"Vest-Pocket" Air-Defense System Defends Field Army Against Attack

A MOBILE "vest pocket" tactical air-defense system which promises nearly instant destruction of hostile aircraft by co-ordinating antiaircraft missile firing at split-second speeds was announced recently by the Department of the Army. The equipment, designated *AN/MSQ-18*, is being deployed overseas by the U. S. Army.

The air-defense system developed for the Army Signal Corps by Hughes Aircraft Company in its Fullerton, Calif., plant is designed to assure almost instant destruction of enemy aircraft attempting to enter a field army's zone of defense. The system gives the air defense commander immediate control over antiaircraft missile batteries even though they might be dispersed over a wide area.

Three principal advantages were cited:

1. *Speed:* Complex electronic data messages travel between elements of the system in milliseconds, assuring "up-to-date" pinpoint positioning of hostile aircraft. Conventional systems require many humans relaying target position by telephone, a time-consuming and error-prone method outmoded by the ever-increasing speeds of modern jet aircraft.

2. *Mobility:* The ruggedly built, highly miniaturized electronic system is mounted in standard, heavy-duty 2½-ton Army trucks, and is capable of being deployed under combat conditions wherever these vehicles can be driven. Work is now under way to provide one verson of this system to be mounted in "helihuts" for movement by helicopter.

3. *Reliability:* Transmission of electronic data between elements of the *AN/MSQ-18* system by digital process greatly reduces the possibility of error. The use of the digital data handling techniques reduces the size and complexity of system components, thus reducing the number of possible failures within a given task.

Brig. Gen. E. F. Cook, acting deputy chief signal officer, Department of the Army, told observers that "we feel that in developing and producing this equipment we have taken a very significant step in modernizing the field army's air defense capability."

System Truck-Mounted

The "vest pocket" air-defense system consists of a truck-mounted operations central, from which an Army battalion commander may observe the air battle, and several battery equipments called coder-decoder units. These units are located at Hawk or Nike batteries, and provide the batteries with electronic data on enemy planes entering the field army's zone of defense. The coder-decoder unit converts electronic data from digital to analog form for use by currently operational missiles.

One operations central is capable of handling several coder-decoders for Hawk antiaircraft missile batteries. When in use, data on the range and bearing of attacking planes is funneled into the operations central from a local antiaircraft detection radar.

The information on aircraft, both hostile and friendly, is displayed on radar indicators in the operations central. A commander on duty can either direct the antiaircraft defense by making assignment of targets to certain batteries or he may merely monitor the battle to make sure his missile batteries are fulfilling their roles in the network.

By the accurate method of electronic digital data handling, the operations central sends target data to the appropriate coder-decoder unit. Here the digital message is converted to analog data which the missile battery uses in conjunction with its "local" radar to launch its missile against a hostile plane.

Operating in the return direction, the status of a battery's defense can be relayed through the coder-decoder to operations central. There the information is used by the commander, or may be relayed to higher headquarters for wider co-ordination of antiaircraft missile fire.

Frescanar

The *AN/MSQ-18* is also an integral part of the Hughes-built Missile Monitor field army air-defense system, presently undergoing evaluation tests at the Army Air Defense Board, Fort Bliss, Texas.

A feature of the Missile Monitor system is a new type of radar called Frescanar, announced by the Army last fall. Frescanar, designated *AN/MPS-23* by the Army, provides range, azimuth, and altitude of an airplane simultaneously by electronically scanning with a pencil-shaped radar beam. With this technique, developed by Dr. N. A. Begovich, Hughes–Fullerton director of engineering, the radar beam is scanned in elevation electronically to provide altitude, while the antenna from which the beam emanates, rotates mechanically to provide range and bearing. The method eliminates the need for a separate height-finding radar system, and permits automatic tracking of hundreds of targets simultaneously. Frescanar is also under evaluation by the board at Fort Bliss.

DEPLOYMENT of the U. S. Army's tactical air-defense system (AN/MSQ-18) is depicted in this panoramic view (above, *left*) of a battalion-level combat area. In foreground, cutaway shows a radar operator at operations central monitoring hostile aircraft picked up by radar at left. Commander with him views screens and makes target assignments to appropriate Army missile batteries among those seen deployed in distance. Inset shows closeup of a missile battery, with its local radar, power supply equipment, and truck in foreground housing coder-decoder unit which is part of the antiaircraft system. Above, *right:* Capt. M. H. Storey (*front*) shows how a local commander can monitor an air battle and assign targets to missile batteries from controls at radarscope of the operations central, which is the command center of the AN/MSQ-18 system. Assisting is radar operator, SP-5 James Herrick. Observing the demonstration is Dr. N. A. Begovich (*standing*), director of engineering, Hughes' Ground Systems Group.

Photographs by Hughes Aircraft Co.

Satellite Capsule and Tiny Instruments Will Test Man's Reactions to Space Travel

A SPACE CAPSULE to simulate living conditions on man's first extended trip into outer space is being built for the department of astroecology of the Air Force School of Aviation Medicine at Brooks Air Force Base, Texas. The space cabin simulator is intended for research use to test the psychological and physiological stresses on men in space.

The capsule is designed for occupancy by two astronauts for a period of 30 days, simulating as closely as possible conditions that would actually be encountered on a 30-day venture into space.

Information obtained from research with this capsule is expected to pave the way for design of living and working accommodations in future extended-trip space vehicles.

The manned satellite capsule, which is under construction at Minneapolis-Honeywell's Aeronautical Division plant in Minneapolis, Minn., is an elliptical steel tank 8 feet high and 12 feet long. Ingeniously condensed within these confines are most of the comforts of home and a complex maze of scientific equipment.

Comfortable, but Lonesome

Air Force personnel selected for the first month-long simulated space flight will find their space home equipped with comfortable executive-type chairs, a bed, sanitary facilities, food, and cooking facilities.

However, along with these comforts, the astronauts will also find that they are completely isolated from the world as they know it, just as they would be on a space flight.

Every effort has been made to simulate the isolation of space. The space men will be unable to see out of their capsule. Their only means of communication will be by radio, and atmospheric noise and disturbance will be superimposed on their radio circuit.

The closed-circuit television cameras used to keep the occupants under constant observation are concealed behind the control panel and will peer through inconspicuous openings. Observation ports on the side of the cabin contain one-way glass which is opaque from the inside.

Records, Ash-Trays

The door of the capsule contains an airlock so that biological specimens can be passed out without appreciably changing pressurization and without direct contact between the astronauts and research scientists outside.

ARTIST'S CONCEPTION shows the living quarters and control panel of the satellite simulator. During their 30-day "orbit," the astronauts will be completely isolated from the world as they know it, just as they would be on a space flight.

In designing the space capsule, engineers started with a list of human requirements for a 30-day period, ranging from air to breathe to recorded music and a place for cigarette ashes.

The next step was to design reliable and compact equipment to serve all of these needs, squeeze it into the capsule, and still leave sufficient living and working area for occupancy by two men.

Starting with man's most basic need—pure breathing air—Honeywell designed and built an atmosphere control system with delicate sensing equipment to measure oxygen, carbon dioxide, nitrogen, and carbon monoxide.

A complex system of controls automatically pumps in oxygen when needed, reduces carbon dioxide through the use of chemical absorption beds, pumps in nitrogen if required, and catalytically filters carbon monoxide.

Electrostatic Filter

Provision was even made for astronauts who might enjoy a smoke. The system includes a high-voltage electrostatic filter to ionize and trap dust and smoke particles.

The space capsule is provided with heating and cooling elements for temperature control, and a humidity control device that can pull moisture from the air and store it along with the water supply.

Food for the "trip" will be nonperishable, so that refrigeration is not required; however, a heating element will be provided to warm up soup and coffee.

The space capsule includes a panel with instruments that record environmental conditions and controls to alter these conditions. Also included are simulated space navigational controls for "flying" the capsule.

Information from the space capsule is piped outside to a highly instrumented console which will precisely record environmental conditions and occupant reaction for study by space medical researchers at Brooks Air Force Base.

Sea Level to 28,000 Feet

Atmospheric controls for the cabin are designed so that either the occupants or researchers at the outside console can vary the pressurization, oxygen, carbon dioxide,

SPACE CABIN SIMULATOR (*left*) is inspected by engineers at Minneapolis-Honeywell's Aeronautical Division where it is being built for the Air Force School of Aviation Medicine. The capsule—an elliptical steel tank 8 feet high and 12 feet long—is designed for occupancy by two astronauts for a period of 30 days, simulating as closely as possible conditions that would actually be encountered on a 30-day venture into space. *Right:* "Comforts" of life in a space vehicle are being welded and bolted into place inside the capsule. Outside the door are television receiver, recorder, and air filtering units, and electric coffee pot (among other things) that will be with the men as psychological and physiological effects of space travel are studied.

THIS AIR FORCE DUMMY is rigged for space tests using miniaturized instruments developed by Boeing which will be used to gather information on how humans react to space travel. Except for the metabolism recorder held by Boeing research engineer Dr. Irving Streimer, all of the data recording devices attached to the life-size model are no larger than a wrist watch. One device is attached to an ear lobe. Another is worn inside the ear itself. Others are strapped around a wrist, a leg, an elbow, and the chest of the test subject. The metabolism measuring instrument was trimmed in size from a standard model weighing more than 100 pounds to the 15-pound device shown.

Boeing Airplane Company Photo

temperature, or humidity. Final control is in the hands of outside monitors. Cabin pressurization, for example, can be varied over the range of sea level to 28,000 feet.

For their daily needs, the space travelers will be allotted 2 quarts of water and 3,000 calories of food. They will have 2 cubic feet of space (about the size of an overnight bag) to store their clothes, and about 2 cubic feet of storage space for personal belongings.

The subjects will be able to tell whether it is night or day only by clocks. Simulated flight conditions and problems will be presented to them on a television screen, to be solved with the controls on their panel.

Miniature Space Test Instruments

Increased comfort for the man in space is being designed into tiny, thumb-sized instruments now being developed by Boeing Airplane Company, Seattle, Wash.

Miniaturized devices for recording pulse and blood circulation rates, blood pressure, body temperature, respiration, and heart action will be worn by crew members during simulated or actual space flights. Instrument data will show how humans react to space travel.

The savings in size and weight are expected to pay off in comfort to the crew and lighter pay loads for space vehicles.

In one case, a standard desk-sized metabolism apparatus is being replaced by a machine no larger than a portable typewriter case and weighing only 15 pounds. The equipment will operate for 4 hours, 16 times longer than standard equipment.

In another case, a rectal thermometer has been discarded in favor of a temperature thermistor smaller than the head of a pin. It will be impacted in a wad of wax and worn inside the ear.

Equipment generally available for testing physical reactions of humans to space environment is cumbersome. Results of a test set up to measure the amount of energy spent in normal walking, for example, may be inaccurate because of the extra energy involved in merely carrying the restrictive, bulky equipment.

By squeezing much of the instrument requirements into tiny packages, designers are saving weight where every ounce literally weighs against the possibility of a successful launching. "It takes 1,000 pounds of thrust to put a pound of payload into orbit" is a rule of thumb of rocket specialists.

An oximeter which measures the concentration of saturated oxygen in the blood has been designed to fit an ear lobe. As small as a thimble, it weighs only 38 grams—one-fourth the weight of its predecessor and one-tenth its size.

Boeing also succeeded in trimming the weight of a respirometer by 75%. Strapped around the chest of a human, it measures the frequency, amplitude, and characteristics of a breathing pattern, providing vital information concerning respiration.

To record blood pressure and pulse, it had been necessary either to bind the subject's arm or pierce his skin with a needle recorder. A device worn like a wrist watch now gets the same information without discomfort.

Chief subject so far in the tests has been "Sierra Sam," a 200-pound U.S. Air Force dummy built to average dimensions of 4,000 human anatomies. He formerly was used to test new seat ejection designs during high speed "bail outs."

After the instruments are completed and tried on the model for size, they will be turned over for use by scientists and engineers anxious to learn how the human body reacts in space.

Future Meetings of Other Societies

The Institute of Radio Engineers
5th National Communications Symposium, Oct 5-7 Hotel Utica, Utica, N. Y. Oct 8: classified symposium, Griffiss Air Force Base, Rome, N. Y. *Confidential clearance required.* J. R. Bernard, Glen Rd., N, Rome, N. Y.

URSI Fall Meeting, Oct 19-21, El Cortez Hotel, Balboa Pk, San Diego, Calif. Mrs. H. E. Hart, URSI US Nat'l Comm, 2101 Constitution Ave, Washington, D. C.

East Coast Aeronautical and Navigational Electronics Conference, Oct 26-28, Lord Baltimore Hotel, Baltimore, Md. G. A. Engelbert, Bendix Radio Div, Bendix Aviation Corp, Baltimore 4, Md.

IAS, 7th Anglo-American Aeronautical Conference, Oct 5-7, Hotel Astor, New York, N. Y. IAS, 2 E 64 St, New York 21, N. Y.

AES, 11th Annual Convention and Professional Equipment Exhibit, Oct 5-9, Hotel New Yorker, New York, N. Y. AES, P O Box 12, Old Chelsea Station, New York 11, N. Y.

SMPTE, 86th Semiannual Convention, Oct 5-9, Statler Hilton Hotel, New York, N. Y. J. P. Weiss, DuPont Photo Products Div., Parlin, N. J.

Armour Research Foundation of Illinois Institute of Technology
Radio Interference Reduction and Electronic Compatibility Conference, joint U. S. Army SRDL, and IRE, Oct 6-8, Chicago, Ill. *Oct. 8: Classified session.* M. J. Jans, ARF of IIT, 10 W 35 St, Chicago 16, Ill.

6th Annual Computer Applications Symposium, Oct 28-29, Morrison Hotel, Chicago, Ill. M. J. Jans, same.

P.E.A., Fall Meeting, Oct 8-9, Pick-Roosevelt Hotel, 6th St at Penn Ave, Pittsburgh. Pa. J. W. Miller, Duquesne Light Co., Pittsburgh, Pa.

ASTM, 3rd Pacific Area National Meeting, Oct 11-16, Sheraton-Palace Hotel, San Francisco, Calif. C. H. Fitzwilson, Columbia-Geneva Steel Div, U S Steel Corp, 120 Montgomery St, San Francisco, Calif.

15th Annual National Electronics Conference (NEC), Oct 12-14, Hotel Sherman, Chicago, Ill. M. E. Van Valkenburg, Elec Engg Dept, U of Ill, Urbana, Ill.

NSPE, Fall Meeting, Oct 15-17, Olympic Hotel, Seattle, Wash. K. E. Trombley, NSPE, 2029 K St, NW, Washington 6, D. C.

The Electrochemical Society, Inc., Meeting, Oct 18-22, Deshler-Hilton Hotel, Columbus, Ohio. R. K. Shannon, Society Hdqrs, 1860 Broadway, New York 23, N. Y.

ASCE, Convention, Oct 19-23, Washington, D. C. ASCE, 33 W 39 St, New York 18, N. Y.

AEC, Symposium on Reprocessing of Nuclear Fuels, Oct 20-21, Richland, Wash. J. T. Christy, Hanford Operations Office, U. S. AEC, Richland, Wash.

SPSE, National Convention, Oct 26-30, Edgewater Beach Hotel, Chicago, Ill. SPSE, Box 1609, Main Post Office, Washington, D. C.

AIME, 1959 Solid Fuels Conference, joint ASME, Oct 27-29, Netherland-Hilton Hotel, Cincinnati, Ohio. H. N. Appleton, AIME, 29 W 39 St, New York 18, N. Y.

ASRE, Semiannual Meeting, Oct 30–Nov 1, Traymore Hotel, Atlantic City, N. J. ASRE, 234 5th Ave, New York, N. Y.

SWAMI—
Tiny Radar Device

A miniature radar-like device that detects and measures movements up to thousands of feet away was demonstrated recently by the Singer Military Products Division.

Named the Standing Wave Area Motion Indicator (SWAMI), the device is small enough to fit into an attache case and is virtually impossible to confound with countermeasures.

What It Is

The SWAMI sensor is a sealed vacuum tube envelope containing an ultrahigh-frequency radio oscillator (2,000 mc) pulsed at a low-frequency repetition rate. This apparatus is shock resistant, and its service life will compare favorably with that of vacuum tubes used conservatively in more conventional applications.

Any motion in, or intrusion into the area under surveillance induces a change in the low-frequency repetition rate which, in turn, is detected by an FM detector. The detector transmits this intelligence to the monitor in a central control station in the form of voltage fluctuation of high amplitude, touching off the alarm.

Any attempt to tamper with the connecting cable leading from sensor to monitor will actuate the alarm.

Power source for the sensor may be either an ordinary household 115-volt outlet or a battery with enough power to supply an ordinary household night light. Any type of battery, wet or dry cell, will serve.

SWAMI was designed by L. B. Mulvey, of West Newton, Mass., who sold exclusive United States and Canadian rights to The Singer Manufacturing Company, of which the Singer Military Products Division is a part, and who has been engaged by Singer-Bridgeport as a production consultant.

Armed services interest in the new device is centered around physical security, including such applications as perimeter protection, battlefield surveillance, range safety applications, and traffic control.

For example, SWAMI would have application on nuclear test ranges to assure the blast area is clear, R. W. Hewey, Singer-Bridgeport works manager, said.

Unlike conventional radar, SWAMI is expected to be used in large quantities because of its versatility and low cost. According to Mr. Hewey, the tiny unit is designed to replace some electronic detection systems costing many times more.

"Although the prime use of the system will be military," said Mr. Hewey, "the system will have many commercial applications."

Protection of bank vaults, police detection of speeding in civilian traffic, and prison security have been put forth as possibilities. Present detection systems require operators, while several of Singer's new devices scattered about an area under surveillance could be "read" by a guard at a central check-point.

Combinations for More Information

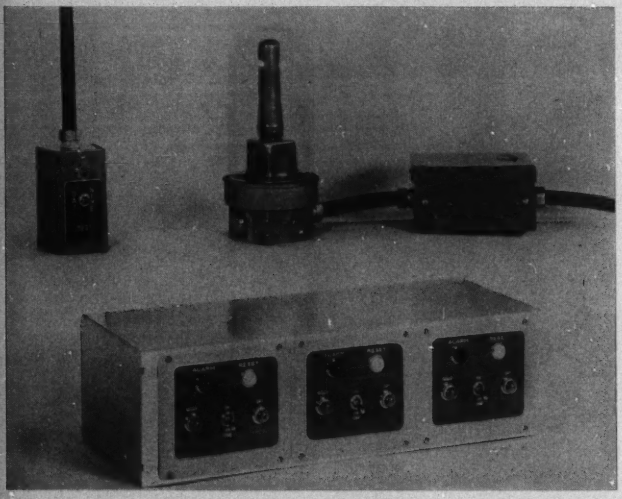
A single SWAMI unit has effective range from a few inches to several thousand feet and, operated without auxiliary equipment, is omnidirectional. However, the propagation angle may be reduced by installation of a parabolic reflector around the antenna. The practical lower limit for portable, highly mobile units, such as might be carried in the field by light infantry, is approximately 15 degrees.

Restriction of the propagation angle would be desirable, for example, if friendly activities were to be carried on within range of the SWAMI. The instrument would then be focused through a narrow angle covering only the area where a hostile movement is anticipated, but would be screened off in such a way that it would not respond to intentional activities elsewhere within the normally effective range of operation.

Determination of Speed

Relative speed of a target can be determined with a single SWAMI unit, and, if the instrument is positioned to focus directly along the line of motion, it will determine the absolute speed. A unit could be beamed directly along a straight stretch of highway so that traffic is moving directly toward or away from the instrument, and a count of the half wavelengths read as a calibration of absolute speed.

Units positioned within range of one another will act in a complementary way to reinforce the amplitude of each.



SWAMI—an intrusion detector security system which saturates a secured area with ultrahigh r-f energy sensitive to the slightest motion or displacement of an intruder—is comprised of the following three units. (1) The Sensor (*rear, right*) is a high-frequency low-power radio transponder sealer in a weather-proof vacuum tube envelope. Plugged into an electrical fixture mounted in the area under surveillance, the Sensor responds to intruder disturbance of the controlled r-f field pattern and transmits a signal over a strictly supervised cable to a sensitivity control box mounted nearby. (2) The Day Nite Sensitivity Control Box (*rear, left*) is mounted within the reach of a guard on a wall or a post in the sensor area. A simple control enables the guard to switch the system from Day operation to Nite operation. During Day operations, the system is sensitive to willful tampering, line failure, critical component failure, or power failure. Normal daily activity in the area will not cause an alarm. Switched to Nite operation, the system provides maximum security against intrusion of, or movement within, the area under surveillance. Rodents or other small animals will not cause an alarm, however. The sensor signal, controlled by the Day/Nite switch, is transmitted over a strictly supervised telephone line to a monitor unit mounted in a central guard station. (3) The Monitor (foreground) is a compact, unitized control panel installed in a console or rack within easy reach of the guard at a central station. Two small lamps indicate Day or Nite operation of the system. A red lamp and a buzzer indicate an alarm. A push-button enables the guard to reset the system when the alarm condition has passed. A "memory" switch enables the guard to silence the buzzer until the alarm condition is cleared, but reminds him to reactivate the buzzer when the system is reset.

Floating Power Plant
Coated with Plastic Insulation

A 5,000-ton ocean-going ship that has been converted into a floating power plant and insulated to withstand temperatures of —50 F was towed recently to an Arctic outpost to supply electric current for a Ballistic Missile Early Warning System station to be operated by the U.S. Air Force at Thule, Greenland.

Originally built by the U.S. Maritime Commission for use as a cargo vessel, it

has the general appearance of any other ship of its class, but there are three major differences: (1) the ship's engines have been removed; (2) the hold now is crammed with generators and other equipment required for a complete steam–electric power plant; and (3) the exterior of the 340-foot vessel, beginning slightly above the waterline and extending upward over the hull, the decks, and all the superstructure, has been covered by a 3-inch layer of modern plastic insulation. The same insulation has been applied to the interior of the ship below the waterline.

Because the ship was scheduled for use in the frigid North, where it probably will be ice-bound in its off-shore berth, the insulation project was considered vital by both the Air Force and the Army's Corps of Engineers, which was responsible for the ship's conversion. High temperatures inside the ship and subzero temperatures outside normally would cause condensation, leading to dangerous icing.

The Borden Chemical Company, New York, N. Y., in collaboration with the Sullivan Plastics Company, developed some modified Epiphen epoxy coatings and adhesives which solved the problem. Used in conjunction with Sullivan-developed sheets of expanded polystyrene, the resins enabled the Army engineers to design an insulating technique that prevented the formation not only of ice, but also of frost.

The technique called for the application, through use of a special adhesive, of sheets of polystyrene to the hull, decks, and entire superstructure of the ship. Several thicknesses of fibered glass mesh then were glued over the polystyrene and the whole thing was coated with a resin that dried to a "battleship gray."

Military leaders decided to use the floating power plant because it could be completed and put into service in a relatively short time. Construction of a permanent building and installation of equipment in the Arctic would have taken too long, they believed. Operating at capacity, the power plant can generate 36,750 kw of electricity per hour. To do this, it produces 135,000 pounds of steam per hour, using approximately 1,250 gallons of fuel.

Engineers Catch Missiles in "Operation Fishhook"

In "Operation Fishhook," U.S. Navy, Lockheed, and Westinghouse engineers are using a giant floating crane in the Pacific Ocean to catch full-scale dummies of the Polaris missile in flight after testing of the underwater launching system.

The novel technique is accelerating development of the Navy's top-priority Polaris fleet ballistic missile while saving millions of dollars by permitting extended re-use of the dummy missiles, the Navy announced.

Fishhook is a retrieving rig that suspends the instrumented Polaris dummy missile in mid-air after it has been launched from a submerged tube duplicating launching equipment now being installed in fleet ballistic missile submarines.

Advanced tests being conducted provide structural data showing effects of under-the-sea launching on prototype missiles. Fishhook prevents them from falling back into the sea and suffering damage which would obscure the desired test information.

Fishhook is in operation at the San Clemente Island sea ranges of the U. S. Naval Ordnance Test Station, China Lake, Calif., and its Pasadena facility. Westinghouse Electric Corporation, Sunnyvale, Calif., prime contractor for launching system development; and Lockheed Missiles and Space Division, also Sunnyvale, Polaris missile system manager and prime contractor, are co-operating on the project.

The seagoing "catch" operation is an outgrowth of "Operation Skycatch," dryland structural testing on which the two contractors are co-operating at San Francisco Naval Shipyard.

Fishhook's engine works on the hydraulic-ram type principle, actuated by compressed air. It reels up the cable attached to the Polaris dummy missile much like a giant fishing reel hauling in a fish. As a Polaris dummy reaches the apex of its flight, the Fishhook braking arrests its fall before it can plunge back into the sea. A system of pulleys multiplies the speed with which the cable is reeled in, to make it compatible with the launch speed of the dummy.

Concept and design of this complex retriever was worked out by engineers of the Navy Air Engineering Facility, Philadelphia, Pa., who applied their long experience with arrestment of naval carrier aircraft. Lockheed contributed a method of attaching the cable to the dummy without affecting the missile's hydrodynamic performance while passing through the water.

The crane barge and derrick were developed by the U.S. Naval Shipyard, Long Beach, Calif. The barge is 100 feet square, and the derrick towers 186 feet above the water and 100 feet out from the barge. Total displacement is 895 tons.

"Pop-up" Program

Polaris has been undergoing "Pop-up" underwater launching tests since January 1958, at San Clemente Island, located 55 miles south of Los Angeles Harbor.

Earlier Pop-up tests were made with a dummy of heavy boiler plate construction which fell back into an elaborate submerged net system. The prototype missile now used is similar to actual Polaris configuration, weight, and construction, and therefore has a much thinner skin which could not withstand the crash into the sea. The actual Polaris missile, now in advanced flight testing at Cape Canaveral, Fla., is designed to ignite after it is clear of the water and roar into space toward a target more than 1,200 nautical miles away.

At the inception of the Pop-up program, the Special Projects Office of the Navy's Bureau of Ordnance, in charge of Polaris weapon system development, planned to have a structurally accurate dummy missile such as that now being used. Fishhook was the answer, and went into very successful operation on April 24, 1959, the Navy reported.

BIGGEST "catch" of the season—a full-scale dummy Polaris missile—is reeled in after successful underwater launching test off San Clemente Island, Calif. Called "Operation Fishhook," the advanced underwater launching program for the U. S. Navy's submarine-launched ballistic missile is being conducted at the sea ranges of the U. S. Naval Ordnance Test Station, China Lake and Pasadena, in conjunction with Westinghouse and Lockheed. In the first photo (above), a column of water follows the multiton dummy missile aloft after ejection from a launcher far below the surface. Five seconds later (below), Fishhook suspends the dummy in mid-air. The instrument package carried inside the structurally accurate dummy has a complete record of effects of launch and water passage, and the test missile is saved from damage of falling back into the sea.

THE HEXAGON, headquarters of the U. S. Army Signal Research and Development Laboratory at Fort Monmouth, N. J., where the laboratory's first Communications-Electronic Presentation was recently held.

Signal Corps Presents Communications–Electronic Show

The U. S. Army Signal Research and Development Laboratory offered emphatic proof of the role of electronics in the nation's defense and in any possible future combat at its first Communications-Electronic Presentation held recently at Fort Monmouth, N. J.

The demonstration was a "state of the art" show, to give potential users and suppliers a broad-band view of what the Signal Lab has developed recently and can develop in the years to come, both internally and under contract.

A wide range of more than 100 items was displayed including fully electronic long distance automatic telephone switchboards, satellite communications systems, the latest in field radios, and automatic flight control devices and Doppler navigators for aircraft.

Project Decree

An attempt to establish world-wide line-of-sight communication will be made sometime during 1961 by the launching of the first of three satellites to an altitude of 19,500 nautical miles. It is hoped eventually to establish an equatorial communication system in synchronous orbit around the equator. The three satellites will form a relay system in a hovering orbit, thus ensuring high propagation reliability and good directional characteristics. Microwave frequencies will be used.

This project is under the Astro-Electronics Division of the Research and Development Laboratory of the Signal Corps.

Sometime during the early part of 1960, the U. S. Army will launch its Courier satellite, an advanced version of the type that delivered President Eisenhower's global Christmas message last December. The Courier, in contradistinction to the satellites in the Project Decree program, will have facilities for information storage. It will operate on coded command to ensure security. It is hoped that this satellite will be the forerunner of a communications system to replace existing high-frequency communication links now used domestically.

Other interesting displays included an an experimental beam waveguide—a new kind of transmission device for low-loss propagation in the region of 100,000 mc; and a binary digital communications system, Selcom, developed by Radio Corporation of America in co-operation with the Signal Corps. Selcom has the capacity to handle 65,536 different addresses and 64 canned messages, and to monitor simultaneously a number of communication channels. The system can be hooked into any existing audio system.

Vehicles and shelters containing the newest military radios were airlifted to the presentation; photographs were taken, radioed to distant points and back, and finished prints were delivered in 5 minutes; one of the world's fastest combinations of teletypewriter equipments received, relayed, and poured forth 750 words per minute.

Displays were housed in four huge tents erected on Colin Kelly field, directly in front of the Hexagon, Laboratory headquarters; dynamic demonstrations were presented on another section of the same field.

Giant Radar To Further the Exploration of Space

When space vehicles go to Venus, scientists on Earth will be able to receive signals from them using a giant radar which Cornell University, Ithaca, N. Y., has designed for a site in Puerto Rico, according to Prof. W. E. Gordon.

Prof. Gordon, addressing an alumni group, said the 1,000-foot radar will enable scientists and engineers to follow the flight of space vehicles more closely than they otherwise could, and would also enable scientists to pinpoint Venus within 500 miles.

"The present estimate of the error in pinpointing Venus' position is 500,000 miles," he declared. "The 500-mile estimate of accuracy is conservative considering the distance to Venus when it makes its closest approach to earth."

Prof. Gordon said repeated observations should reduce this error to 100 miles, which is very close to the error introduced by the accuracy with which the speed of light is known. He said the pinpointing of Venus would improve the scale of the complete solar system map.

The big radar will permit scientists and engineers to study the cloud-covered topography of Venus and to learn more about the electrical properties of the planet's atmosphere. The detector also will be used to study the moon, the sun, Mars, and perhaps Jupiter. "Jupiter is so far away, however, that observations will be difficult," the Cornell engineer declared. He explained that the round-trip travel time of a radar pulse to Jupiter is 70 minutes.

The big instrument is still on the drawing board, but Prof. Gordon hopes it will be completed by April 1961, when Venus reaches its closest point to earth. To be constructed in a limestone sink in Puerto Rico, the detector will be the size of two football stadiums.

The radar will probe into mysteries of space which once seemed accessible only to artificial satellites. However, the device will not be a substitute for satellites but will supplement and free them for other tasks. It will transmit facts about electron density and temperature much more quickly and cheaply than satellites.

The project was touched off by Prof. Gordon's discovery that electrons in outer space can be detected with extremely powerful radar units. Electrons higher than 60 miles above the earth's surface scatter conventional radar waves so weakly that they have not been seriously considered by most scientists.

Prof. Gordon has shown that a radar the size of the one being planned will give scientists and engineers new knowledge of subatomic matter in outer space. It may also yield new information about the weather.

Visible evidence that radar can be used in this way was obtained by Dr. Kenneth Bowles, of the U.S. National Bureau of Standards in Boulder, Colo., shortly after Prof. Gordon made his proposal. Dr. Bowles' radar unit in Long Branch, Ill., picked up reflections from charged particles in the ionosphere about 180 miles above the earth's surface. Dr. Bowles combined several small antennas to make the exploratory space probe. His instrument was not sensitive enough to pick up a great deal of information, however.

Announcement

The SEATO Graduate School of Engineering is being established in Bangkok, Thailand, under the direction of Colorado State University Research Foundation through a contract with International Co-operation Administration. A comprehensive reference library is planned to serve the staff and students, initially in the field of civil engineering and later in electrical engineering and mechanical engineering.

If you have, or know of anyone who has, engineering literature in the form of periodicals, books, manuals, microfilms, special reports, etc., a contribution to this library would be very valuable. Please write to: Dr. M. L. Albertson, Director, Colorado State University Research Foundation, Fort Collins, Colo.

Puerto Rico was chosen as the site for the big dish because of its low latitude and because the area has natural limestone depressions in which the scanner can be constructed.

Electron Emission from Silicon Carbide Discovered

Electronic tubes may some day be "transistorized," if practical use can be made of a recently discovered effect by which it is possible to obtain a constant flow of electrons directly out of the surface of certain semiconductor materials.

Research physicists at Westinghouse Electric Corporation, Pittsburgh, Pa., report that the latest semiconductor to yield this unique flow of electrons is silicon carbide—a hard, crystalline solid best known for its widespread use in impure form as an abrasive in grinding wheels. The density of the electron flow or "emission," they find, is equal to that in the average electronic tube.

An electronic tube functions by regulating the flow of a stream of electrons across a vacuum inside it. Conventionally, these electrons are obtained by boiling them out of a coated metal wire, or cathode, at high temperatures. Considerable electric power is required to supply the necessary heat, which then must be dissipated to prevent overheating of the tube itself.

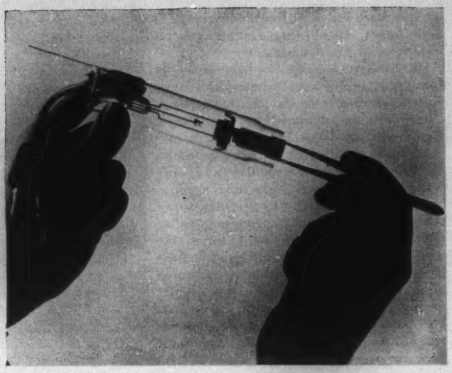
"Applied successfully to a vacuum tube, this new method of electron emission from semiconductors would do away with this whole inefficient process," Dr. Clarence Zener, director of Westinghouse research, declared. "One can visualize a tube in which the usual heated cathode is replaced by a small semiconductor crystal having a built-in 'junction' like that in a transistor. The crystal would consume a negligible amount of power and would yield electrons instantly and indefinitely when a small electric voltage is applied across it." It was felt that such a device would, in effect, combine in a single operating unit many of the inherent advantages of both semiconductors and vacuum tubes, resulting in what might be called a "solid-state" electronic tube.

The escape of electrons from silicon carbide, discovered by Dr. W. J. Choyke and Dr. Lyle Patrick, of Westinghouse, accompanies the emission of visible light from the crystal. This visible light is a form of electroluminescence, and occurs when enough voltage is applied across the junction to cause breakdown, or loss of the junction's normal electrical resistance.

When breakdown occurs, small blue spots of light appear in the crystal in the region of the junction. Electrons escape from these bright, light-emitting spots, especially from those located nearest the surface of the crystal. From the spots, which are only about 50 millionths of an inch in diameter, the scientists have measured currents up to one millionth of an ampere, indicating that the density of the electron flow is quite comparable to that from the cathode of a typical vacuum tube.

Although a millionth of an ampere is a small current by everyday standards, many electronic tubes, such as beam-type camera and display tubes used in television and military electronic systems, may use considerably less current. This perfectly adequate flow of electrons originates from a tiny, pin-point source. Such a source would have many advantages in the construction of complicated tubes. It would simplify focusing of the electron beam and eliminate much of the complicated tube construction now employed for this purpose.

In view of the present-day emphasis upon miniaturization of electronic equipment, elimination of the large, hot, power-consuming cathode would be a major advance in electronic tube development.



EXPERIMENTAL electronic tube gets its supply of electrons from tiny crystal of silicon carbide which is inside cartridge being inserted into the tube.

Westinghouse Photo

Iodine Cycle Used To Eliminate Lamp Blackening

Announcement has been made of a new line of lamps which utilizes the principles of a repeating iodine cycle. This cycle is a regenerative, continuing process which catches the particles of tungsten that evaporate from an incandescent lamp filament and actually puts these particles back on the filament. In other filament lamps, these particles mass on the bulb and cause a gradual loss of light output. However, the iodine cycle used in the "Quartzline" lamps, produced by General Electric Company (GE), Cleveland, Ohio, eliminates this lamp blackening by its action.

PRECISE optical control of light from GE Quartzline incandescent lamps is demonstrated in a simple lightweight lensless reflector developed by C. J. Allen, application engineer. Such control will permit bright, efficient lighting for industrial areas, sports fields, and building facades.

Traces of iodine gas in the mixture filling the tube combine chemically with the evaporating tungsten particles. The iodine, plus the lamp's heat, prevents the tungsten from accumulating on the inside of the lamp wall and darkening it. As the tungsten–iodine compound circulates back into the area of the incandescent filament, the filament's great heat frees the tungsten from the compound, leaving the iodine free to start the cycle again.

According to GE scientists, if the evaporating tungsten particles could be returned to the filament in a perfectly even coating, theoretically a lamp might never burn out. But since there is no way to control exactly where the tungsten particles return to the filament, one spot will wear out eventually. At this point, the filament breaks, ending the lamp's life.

Quartzline lamps, which are to be available first in 500- and 1,500-watt sizes, must be operated horizontally to maintain the iodine cycle properly. They operate at relatively high temperatures which require that they be screened from accidental contact. However, under normal conditions they will need no cleaning while in service, since the heat of the lamps will incinerate most dust particles settling upon them.

The Quartzline lamps consist of a coiled tungsten filament supported at intervals through a quartz tube $\frac{5}{8}$-inch in diameter. On each end is a miniature recessed-contact base suitable for push-pull socketing like that popularized for slimline fluorescent lamps.

The 500-watt lamp is just over $4\frac{1}{2}$ inches long and operates on standard 120-volt power, producing 10,500 lumens. The 1,500-watt lamp is about 10 inches long and is designed for 277-volt operation. It is rated at 33,000 lumens. Its total volume is only 0.5% of a standard 1,500-watt PS-52

general service lamp now commonly used by industry. Rated life of both lamps is 2,000 hours, double that of their general service lamp counterparts.

Simple lensless reflectors have been devised for the 500-watt tube which throw its beam in a rectangular or square beam. These can be designed to light show windows, sports fields, bulletin boards, and do general floodlighting. Other reflectors can produce a long rectangular beam only 6 degrees wide which could have application in lighting building facades, store counters, and golf driving ranges. Smaller iodine cycle lamps are being tested for lighting airport runways, and another such lamp is being tested as a light source to grow algae, a possible food and oxygen supply for space travel. Use of the Quartzline lamp type in homes is not immediately foreseen by the company's scientists.

Scientists Foresee Automatic Transistor Production

Scientists at the Westinghouse research laboratories have taken a major step toward the fast, continuous, completely automatic manufacture of transistors and related semiconductor devices.

Dr. S. W. Herwald, Westinghouse vice-president, research, disclosed that Westinghouse scientists have constructed long ribbons of semiconductor devices by forming them along the surface of long, thin crystals of germanium about 1/8 inch wide and a few thousandths of an inch thick. Such construction appears to be feasible for the automatic production of transistors and other solid-state devices directly by machine.

"These devices demonstrate the ultimate usefulness of a revolutionary new method for growing germanium which was recently discovered in our laboratories," Dr. Herwald said. "This technique grows the germanium as thin, flat continuous strips, or dendrites—the exact form in which it can be used directly in finished semiconductor devices."

Conventionally, germanium is grown as a thick, round ingot that requires costly, time-consuming processing before useful devices can be produced from it. In contrast, such devices can be constructed directly on the smooth, mirror-like surfaces of germanium dendrites exactly as the material is grown.

The development of working devices from dendrites is being carried out under a $2 million "molecular electronics" contract recently awarded to Westinghouse by the U. S. Air Force's Air Research and Development Command, Dr. Herwald reported.

Carried through to the development of over-all systems, the molecular electronics concept could drastically reduce the size, weight, and power consumption of space-age electronic systems. This concept involves a new understanding of the basic nature and capabilities of materials and a new approach—on a molecular and atomic scale—to the conception, design, and development of materials that exhibit these capabilities.

Two Westinghouse research physicists, Dr. R. L. Longini and Dr. A. L. Bennett, developed the new germanium growing technique.

"Useful semiconductor devices are made from a dendrite simply by constructing them directly on its surface," Dr. Longini reported. "Any desired number of devices can be built on a single dendrite to form a long, continuous strip of devices. Or, if desired, the individual devices can be separated from the group simply by cutting the dendrite into small pieces."

In addition to the long experimental strips of devices, hundreds of individual functioning units have been prepared from germanium dendrites by the Westinghouse semiconductor department at Youngwood, Pa.

A METHOD for growing germanium and other semiconductor materials, discovered by scientists at the Westinghouse research laboratories, may make the manufacture of transistors and similar semiconductor devices fully automatic. This "hand built" version shows how it might be done. The devices are formed as a continuous series of dots along the long, thin, mirror-flat surface of the crystal. Electric connections are then made to the dots, after which they are separated from the germanium strip. Placing the unit in a plastic or metal container completes the process. Westinghouse scientists see no reason why the whole process cannot eventually be done automatically by machine at high speed and with high reliability.

Underwater Camera Can Explore Deepest Ocean Waters

An automatic underwater camera has been designed to probe the unseen ocean bottom to depths of 6 miles. Developed by the scientific instrument firm of Edgerton, Germeshausen & Grier, Inc., Boston, Mass., the new camera, housed in a tempered steel casing to withstand pressures of 8 tons per square inch, can take up to 500 photographs at 10-second intervals on 35-mm film. A built-in data-recording compartment records time and other vital information with each exposure directly on the film.

Earlier models of the underwater camera, designed and developed by Dr. H. E. Edgerton, of the Massachusetts Institute of Technology, were used in a National Geographic Society expedition headed by Commander Jacques-Yves Cousteau several years ago. At that time, the camera successfully photographed the 25,000-foot deep Romanche Trench, the equatorial mid-Atlantic crevasse between Africa and South America.

Several experimental underwater cameras developed by the company for National Geographic Society expeditions, the Woods Hole Oceanographic Institute, the U. S. Naval Electronics Laboratory at San Diego, Calif., and others, have taken photographs in most of the oceans of the globe.

The improved camera has an electrically controlled shutter synchronized to an electronic flash of 100-watt-seconds capacity. The unit weighs about 50 pounds, is 22 inches long, and 5 inches in diameter. A companion model, fitted with a shallow case, is designed for submergence up to 2,000 meters. Equipped with the shallow or deep water case, the underwater camera will cover 90% of the needs of oceanographic photography, according to the company.

Nuclear-Powered Surface Ship

LATEST DEVELOPMENTS in reactor technology are incorporated in the 2-reactor plant of the U. S. Navy's first nuclear-powered surface ship, the cruiser *Long Beach*. The reactors were designed and developed by Westinghouse Electric Corporation under the direction of and in technical co-operation with the Naval Reactors Branch, U. S. Atomic Energy Commission, at the AEC's Bettis plant, Pittsburgh, Pa., operated by Westinghouse. The Navy's Bureau of Ships and the Bethlehem Steel Company were responsible for the over-all ship and nuclear propulsion plant designs. The two pressurized water reactors are said to be larger than that of the *Nautilus*. The *Long Beach* is about 721 feet long, has a beam of about 73 feet, and displaces about 14,000 tons.

Computers To "Talk" English, Algebra, and Logic

A new language to simplify communication between men and electronic computers has been developed by International Business Machines Corporation (IBM), White Plains, N.Y.

The language, called Commercial Translator, combines English with algebraic equations and logical expressions. Commercial problems like payroll, inventory control, and manufacturing scheduling will be stated in the new language. Inside the computer these statements will be converted automatically into detailed machine instructions.

The resemblance to conventional English is close enough so that a person unfamiliar with computer programming can be trained to read and write in Commercial Translator in a matter of days. There are rules for sentence formation, use of suffixes, and even punctuation. A typical statement in the new language which might be used to reorder when stocks are low would read as follows: IF STOCK LEVEL IS LESS THAN 1000 OR RESERVE LEVEL IS ZERO THEN SET ORDER AMOUNT EQUAL TO 5000-STOCK LEVEL; MOVE RECORD TO ORDER FILE; GO TO NEXT ITEM.

In order to write the new language, IBM researchers analyzed a tremendous number of commercial problems being processed by electronic computers. They discovered that these problems could be described in terms of 15 basic computer abilities such as logical decision making, arithmetic, editing, and similar data-handling functions. They were able to construct a language based upon these 15 abilities.

A typical handwritten program may have 10,000 instructions and take 3 to 5 man-years to write. A similar program in the new language can be written in half a man-year. Checking and correcting programs will involve much less machine time because of the relatively few statements in which the problem can be written. Special reports for management can be written in a fraction of the time formerly necessary.

As new computers are designed, Commercial Translator can be easily adapted to them with the use of an intermediary translating program which converts the new commercial language into machine instructions. IBM is now preparing such programs for several of its more advanced data-processing systems, the *705-III*, *7070*, *709*, and the *7090*.

New NBS Standards for Measuring Candlepower

New photometric standards for measuring the candlepower, or luminous intensity, of electric lamps are now available from the National Bureau of Standards (NBS), U. S. Department of Commerce, Washington, D. C. They consist of 100-, 300-, and 500-watt lamps with inside-frosted T-20 bulbs, C-13 monoplane filaments, and medium-bipost bases. These lamps are easily oriented on the photometric bar by means of the bipost bases, require no

National Bureau of Standards Photo

NEW 100-WATT lamp standard is adjusted on the photometric bar for calibration by S. W. Wilson of the National Bureau of Standards photometry and colorimetry laboratory. A barrier-layer cell photometer at the far end of the bar is shielded by baffles.

diaphragm when in use, follow closely the inverse square law, and are superior in the amount of candlepower variation they show with change in orientation to the clear-bulb lamp standards previously issued.

For many years coiled-filament clear-bulb lamps have been employed as reference standards for candlepower. However, the coiled filament has led to a problem of alignment in these lamps which has sometimes been difficult to overcome. In a recent study by L. E. Barbrow and S. W. Wilson of the NBS photometry and colorimetry laboratory, variations in intensity up to 10% were noted when the clear-bulb lamps were tilted through an angle of 5 degrees.

In order to provide standards that could be more easily used by commercial laboratories, an inside-frosted lamp was designed with its filament, filament supports, and base posts in the same plane. Tests showed that because of the frosted bulb, little or no variation in candlepower occurs with change of lamp orientation, either in tilt or rotation about the lamp axis. In addition, it was found that the lamps follow the inverse square law to within 1.0% for distances of 50 centimeters or greater between lamp and photometer, and to well within 0.5% for distances of 1 meter or greater. These distances are measured from the plane of the base pins to the photometer.

A study was made of the effect of filament displacement from the center of the bulb. Two lamps were fabricated with the filament displaced 1 centimeter from the plane of the center of the base posts, which was approximately 1 centimeter from the center of the lamp bulb. The study showed the inverse square law was closely followed if distances were measured to the plane of the filament, and not to the center of the bulb.

Accordingly, in calibrating the inside-frosted standards at the NBS, the distance from photometer to lamp is measured to the center of the filament supports near the base posts (where they are visible through a clear portion of the bulb), or to the center of the base posts, or to the center of the base-post socket holes. With any of these procedures the distance may be measured accurately to the filament plane.

Seismic Recorder Developed by French Firm

The boom of Sahara oil has forced many technical advances in France. Chief among them is the first magnetic seismic recording system produced outside the United States, which was displayed at the World Petroleum Congress held in the Coliseum, New York, N. Y., in June 1959.

The *EMS-11* by LIE-BELIN of Paris, France, will be field tested in France and in North Africa in the very near future.

Though somewhat similar magnetic seismic systems have been produced in the United States for several years, many countries cannot buy this equipment because of lack of dollars. LIE-BELIN's *EMS-11* is, in addition, more up to date, is of new design, incorporates the most recent and advanced technical knowledge, and is completely portable.

The complete recorder, consisting of six portable cases, makes possible the recording of seismic refraction and reflection measurements, and permits playback and transcription in the field. These cases contain a magnetic tape drum unit, a monitor Teledeltos paper chart recording unit, a control unit, two amplifier-modulator units, and a power supply. An auxiliary supply is also provided.

Two basic advances are achieved by the *EMS-11:*

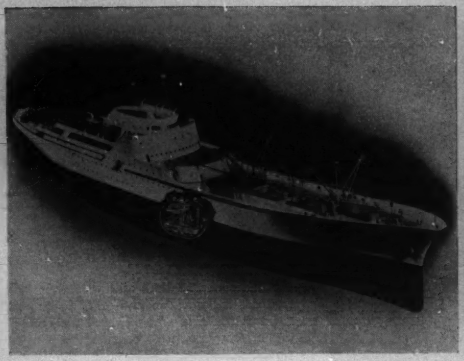
1. *Economic*—its selling price compares very favorably with the cost of similar equipment. Moreover, it is available to those countries that want to explore or expand oil potentials but lack American dollars.

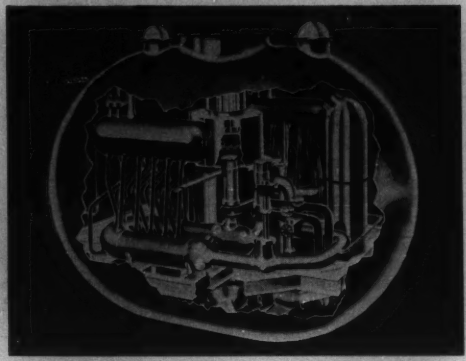
2. *Technical*—it offers an improved programmed gain control which is recorded optically on film. The *EMS-11* also provides for overmodulation and field simultaneous monitoring on three channels, and has channel switching facilities.

The gain-control program is transduced by a 2-photocell system controlling the gain of 24 seismic amplifiers, as a function of the time elapsed since the instant of firing. The film, therefore the program, is easily interchangeable. The automatic gain control is recorded on a film wrapped on a drum. This gives great flexibility in field use. The program may be determined according to any preselected law.

There are 30 tracks altogether, 24 of which are connected to seismic amplifiers. The six additional ones are shot-time, up-hole geophone, time base, modulation carrier, stand-by magnetic head, and logarithmic amplifier to measure the rate of change of the energy of a track. All 30 tracks can be recorded at the same time.

The magnetic-to-graphic transcription can be performed on an individual channel





THE *N.S. SAVANNAH*, world's first nuclear-powered merchant ship *(above, left)*, is able to steam around the world on an "Atoms for Peace" mission—without a puff of smoke. The absence of smoke stacks gives the *Savannah* a sleek look, all because of her nuclear "heart." This cut-away view shows the position of the containment vessel, containing the pressurized water reactor and related reactor system components, as designed by The Babcock & Wilcox Company. Truly a queen, her vital statistics are: passenger accommodations for 60; cargo capacity for 10,000 tons; normal cruising speed of 21 knots; normal cruising range of over 300,000 miles and 3½ years on one loading of fuel; 587 feet long; 78-foot beam; 29½-foot draft; and manned by one of the most select and thoroughly trained crews ever assembled for one ship. States Marine Lines will operate the *N.S. Savannah*. *Above, right:* Located deep amidships, the secondary shielding and containment vessel houses the pressurized water reactor and all other primary components that will be radioactive. In the center is the reactor and its primary shield tank. The spider-like units are the heat exchangers *(bottom)* and steam drums *(top)*. The bullet-shaped unit at the right is the pressurizer, which maintains the primary system at a constant pressure of 1,750 pounds per square inch. The primary piping is shown between the reactor, pumps, and boilers. The entire containment vessel shown here is covered with a 6-inch layer of lead and a 6-inch layer of polyethelene.

Courtesy The Babcock & Wilcox Co.

basis or by mixing the data from three channels to any desired ratio or direction. The transcription is fully automatic and takes only 2½ minutes.

Three patch-panels, one at the amplifier input (2-wire type) and two at the record and playback heads, permit a larger measure of operational flexibility. This provides for instant availability of the auxiliary tracks in the desired position.

Television Cameras Expose Savannah's Nuclear "Heart"

The nuclear "heart" of the *N.S. Savannah* was laid open pictorially by two television cameras while it generated energy for the world's first atom-powered merchant ship.

Passengers in the ship's main lounge were able to see, via Radio Corporation of America (RCA) television cameras, a nuclear reactor working at its mighty task of producing steam for the *Savannah's* conventional turbines. The pulse or "heart beat" of the reactor also was relayed over an accompanying audio hookup.

The 21,000-ton vessel, christened July 21, 1959, by Mrs. Dwight D. Eisenhower at the Camden, N. J., yards of the New York Shipbuilding Corporation, is designed to run 3 years, or 300,000 miles, without refueling. The vessel was proposed originally by President Eisenhower as a demonstration of "peacetime use of atomic energy, harnessed for the improvement of human living."

The reactor is housed in a "containment vessel" below decks, an area not open to the 60 passengers the ship accommodates. However, the RCA television cameras were mounted so they could be "panned" to provide a complete view of the reactor compartment.

By means of a switching system in the ship's control center, the television picture of the propulsion unit was transmitted over a closed circuit to a 6-by-8-foot television projection screen in the lounge. The cables leading to the cameras were installed through the chamber wall with a special "potting" process to prevent any radioactivity from seeping out from the containment vessel.

J. J. Graham, general manager, communications and industrial electronic products operations division, disclosed that two RCA Radiotelephone units were to be installed on the *Savannah* to enable passengers to make ship-to-shore calls. The radio system also will supply an added safety factor and communications link to the ship's operation.

One of these units is an RCA *ET-8060* Radiotelephone with the transmitter and receiver in the vessel's radio room.

As an additional feature, the *Savannah's* closed-circuit television system will provide entertainment for passengers and crew. Motion-picture films and other program material will be fed to RCA television receivers in the main lounge, the ship's bar, officers' lounge, and crew's lounge. Moreover, provision is also made for equipping 37 staterooms with television sets.

Motion pictures can be transmitted to the large main lounge screen as well and, when the *Savannah* is close enough to land, standard entertainment television broadcasts can be picked out of the air.

Except for its atomic power supply, which replaces the customary fuel and boilers, the *Savannah* is very much like any modern merchant ship.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AUTOMATION AND COMPUTING. By A. D. Booth. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 158 pages, 5¼ by 8½ inches, bound. $5. After presenting an historical background of automation and of analog and digital calculation, the author discusses the logical design of calculating machines and the application of digital and analog techniques to automatic process control, machine tool control, and assembly. The achievements of computing machines in various fields are assessed, including that of sports and translation, and it is shown that automation can play an important part in office procedure and in strategic and economic planning.

DICTIONARY OF RADIO AND TELEVISION TERMS. By L. Bizzarri. W. S. Heinman, 400 E. 72nd St., New York 21, N. Y., 1958. 393 pages, 4¼ by 6½ inches, bound. $6. This Italian-English and English-Italian dictionary provides an up-to-date compilation of terms in the fields of radio and television. Included are a list of the principal symbols with their definitions and 11 pages of abbreviations used in these fields.

THE EFFECT OF RADIATION ON MATERIALS. Volume III. Published as Special Technical Publication No. 253 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1959. 168 pages, 6 by 9 inches, bound. $4.25. This volume includes papers providing new data on dosimetry techniques, radiation facilities and techniques, and radiation effects on reactor materials and various other materials.

ELECTRIC ENERGY CONVERSION. By Y. H. Ku. The Ronald Press Company, 15 E.

26th St., New York 10, N. Y., 1959. 522 pages, 6¼ by 9¼ inches, bound. $10. A unified treatment of the theory of electrical machinery is achieved by approaching the subject from the standpoint of the underlying principles of electromechanical energy conversion. Among those topics discussed are d-c machines, theory of transformers, 3-phase systems and instantaneous components, synchronous machines, nonsalient-pole machines, instantaneous torque, interconnection of synchronous machines and stationary networks, induction machines, and servomotors and synchros.

ENGINEERING STATISTICS. By A. H. Bowker and G. J. Lieberman. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y., 1959. 585 pages, 6¼ by 9¼ inches, bound. $11. Statistics is presented as a science for making decisions. Following an introduction to the basic fundamentals of probability and distribution theory, a coverage is provided for both the theoretical aspects and practical applications of the normal distribution; the chi-square, *t*, *F*, binomial, and Poisson distributions; significance tests; tests about one and two parameters; estimation; fitting of straight lines; analysis of variance; quality control; and sampling inspection. Liberal use is made of operating characteristics curves to assist in grasping more difficult statistical concepts, and selected examples are used to solve a wide variety of typical engineering problems.

FONCTIONNEMENT ET PROTECTION DES RÉSEAUX DE TRANSPORT D'ÉLECTRICITÉ. By Pierre Henriet. Gauthier-Villars, Paris, France, 1958. 372 pages, 6¼ by 9¾ inches, bound. 2,800 fr. Based on a series of lectures by the author, this book is limited to a study of a-c networks along which the generating plants and consumers are situated no further apart than 400 to 500 km. It covers the practical calculation of voltage and of active and reactive power and their regulation in meshed networks, the calculation of short-circuit currents in complex networks, and the definition of impedances which limit these currents. The book concludes with a discussion of stability and instability in power networks, and the systems used to protect power lines against short circuits.

GRUNDLAGEN DER SELBSTTÄTIGEN REGELUNG. Band I. By W. W. Solodownikow. R. Oldenbourg Verlag, Munich, West Germany, 1959. 727 pages, 7¼ by 9½ inches, bound. 65 DM. This German translation from the original Russian is the first of two volumes on the fundamentals of automatic control. It deals with the theory of linearized control systems: the basic mathematics; stability analysis of systems; quality analysis and synthesis of correcting devices, and the theory of impulse regulation; and problems in control systems under random circumstances. The presentation is both extensive and detailed.

INTRODUCTION TO THE THEORY OF SOUND TRANSMISSION. By C. B. Officer. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1958. 284 pages, 5¾ by 8¾ inches, bound. $10. Transmission of sound is discussed with specific application to transmission in the ocean. The fundamental relations and general theory underlying the theory of sound transmission are presented and then followed by transmission in shallow water, transmission in deep water, reflectivity, and attenuation. Mathematical derivations are developed in some detail, and physical explanations of theoretical results are given where possible. Modern advances are covered with particular emphasis on developments during the past 20 years.

LECTURES IN APPLIED MATHEMATICS, Volume I. PROBABILITY AND RELATED TOPICS IN PHYSICAL SCIENCES. By Mark Kac. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1959. 266 pages, 6¼ by 9¼ inches, bound. $5.60. An introduction to probability theory, intended to convey the breadth of the subject and to demonstrate its manifold applicability from number theory to physics is given. Papers are included which deal with the nature of probabilistic reasoning, tools and techniques of probability theory, probability in some problems of classical statistical mechanics, and integration in function spaces and some applications. The presentation of the material is based on a series of special examples and problems without any attempt to fit it into any general schemes or theories. This book is the first of four which are to contain the proceedings of the Summer Seminar on Applied Mathematics held at the University of Colorado in 1957.

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LEHRBUCH DER HOCHFREQUENZTECHNIK. Band II. By Fritz Vilbig. Fifth edition. Akademische Verlagsgesellschaft, Frankfurt am Main, West Germany, 1958. 735 pages, 6½ by 9½ inches, bound. 48 DM. Volume II of this treatise on high-frequency technique covers a considerable range of topics: oscillators and transit time amplifiers, couplings and connectors for electronic circuits, rectifiers and stabilization methods, modulation and demodulation, keying and impulse modulation, frequency transformation, amplifiers in the frequency range where transit time effect plays no part, volume control and clipping, and a brief section on shielding.

MODERN ELECTRONIC COMPONENTS. By G. W. A. Dummer. Sir Isaac Pitman & Sons, Ltd., London, England, 1959. 472 pages, 5½ by 8½ inches, bound. 55s. A comprehensive survey of the more common electronic components is presented, together with information on their behavior under the arduous environmental conditions to which they are frequently subjected. Components described include resistors, capacitors, wires, r-f cables, plugs and sockets, relays and switches, inductors, transformers, transductors, and pulsactors. In addition, chapters are given dealing with component specifications, transistor-circuit components, reliability, and future developments. Selected bibliographies are given for the various topics included.

NON-DESTRUCTIVE TESTING. By J. F. Hinsley. Macdonald & Evans, Ltd., London, England, 1959. 495 pages, 6 by 9 inches, bound. 75s. This broad survey of the field of nondestructive testing discusses such aspects as the production and properties of X rays, gamma rays, radiological examination, ultrasonic vibrations and testing, surface flaw detection with and without magnetic particles, sorting of mixed materials, and miscellaneous methods of non-destructive testing. In addition, there is a discussion of diffraction, safety precautions in radiological laboratories, and the interpretation and presentation of test results.

NUTZENERGIE AUS ATOMKERNEN. Band I. By K. R. Schmidt. Walter de Gruyter & Company, Berlin, Germany, 1959. 594 pages, 7 by 9½ inches, bound. 106 DM. The book presents a comprehensive treatment of the practical use of nuclear energy. Beginning with a brief discussion of the fundamentals of nuclear physics, the author continues with reactor theory and the types of reactors. The materials involved and methods of operation are discussed, including moderators, refrigeration, and shielding. Heat power generation, including thermodynamics, is covered; special chemical problems are dealt with; and the book closes with the preparation of fissionable fuel elements.

OPERATIONS RESEARCH. By Maurice Sasieni and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 316 pages, 5¾ by 8¾ inches, bound. $10.25. This text begins with a brief survey of the elements of probability theory, including the concepts of probability of an event, random variable, probability distribution, and conditional probability distribution. Sampling is then discussed, and an introduction is given to the Monte Carlo method of simulated sampling. Succeeding chapters present various problem areas in operations research, specifically: inventory, replacement, waiting lines, competitive strategies, allocation, sequencing, and dynamic programming.

A PRIMER OF PROGRAMMING FOR DIGITAL COMPUTERS. By M. H. Wrubel. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 230 pages, 5¾ by 8¾ inches, bound. $7.50. The book provides an introduction to electronic computing for scientists and engineers who are planning to use electronic computers as tools of research. Although the IBM *650* is used in the examples given, the general techniques described are applicable to practically all stored-program computers. Topics discussed include the approach to simple problems; loops and branches; flow diagrams, subroutines, and the program library; testing programs; automatic programming; arithmetic instructions in machine language; and SOAP. Practical programs are included throughout the text.

PRINCIPLES OF DIRECT-CURRENT MACHINES. By A. S. Langsdorf. Sixth edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 363 pages, 6¼ by 9¼ inches, bound. $8.50. An analysis is presented of the operating characteristics of d-c generators and motors based on the relations between the magnetic and electrical circuits that constitute their structural design. Design considerations that determine the dimensions of machines are touched upon only incidentally. The author discusses armature windings and electromotive force; excitation of the main field; armature reaction; operating characteristics of generators and motors; control of motors and generators; and efficiency, rating, heating, and commutation. In this edition, the chapter on armature windings has been completely rewritten and simplified, and includes a description of a new type of unipolar generator.

PROGRAMMING BUSINESS COMPUTERS. By D. D. McCracken and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 510 pages, 6 by 9¼ inches, bound. $10.25. Intended for the person involved in day-to-day application of electronic computers to business data-processing problems, the book begins with such fundamental concepts as the central concept of the file, flow charting, and the general characteristics of electronic computers. Numerous examples are then given to explain the standard techniques of coding. These examples are written in terms of a hypothetical computer called DATAC which is a compilation of the features of many machines. Also included are such advanced techniques as timing estimates, file organization, automatic coding, and random access storage devices. The authors conclude with a summary of the steps involved in establishing a computer application, and an examination of the accounting and auditing problems associated with electronic data processing.

RESEARCH TECHNIQUES IN HUMAN ENGINEERING. By Alphonso Chapanis. The Johns Hopkins Press, Baltimore 18, Md., 1959. 316 pages, 6¼ by 9¼ inches, bound. $6. The book describes various methods available to the human engineer for collecting trustworthy data on men and machines and the relations between them. Methods of direct observation are considered and characterized by observation of an actual work situation. Methods for the study of accidents and near-accidents are then discussed, followed by material on statistics and experimental methods. The book concludes with the general problems involved in experiments on people, the psychophysical methods, and the articulation test methods used in studying speech-communication systems.

SERVOMECHANISMS AND REGULATING SYSTEM DESIGN. Volume I. By Harold Chestnut and R. W. Mayer. Second edition. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 680 pages, 6 by 9¼ inches, bound. $11.75. The nature of the feedback control system problem is described and an analytical approach to servomechanism and regulator design is presented. Emphasis is placed on the complex plane, the attenuation-frequency, and root-locus methods of control system analysis of both simple and more complex systems. In conjunction with the multiple-loop systems, techniques are described for handling complicated control problems with

simplified analysis methods. The use of these methods permits the designer to arrive at a workable design fairly readily. The present edition reflects recent advances within the field.

TECHNOLOGIE DES RÉACTEURS NUCLÉAIRES. Tome 1: Matériaux. By Paul Ageron and others. Éditions Eyrolles, Paris, France, 1959. 567 pages, 6½ by 9½ inches, bound, 6,900 fr. An introduction to the fundamental concepts of nuclear technology is presented. The effects of radiation on various materials are analyzed and classified. This is followed by a discussion of the behavior of reactor materials, their mechanical properties and radiation damage, as well as the modification of physical properties or the formation of new substances. Nuclear fuels and nonfissionable materials provide the subject matter for seven chapters, while recent developments in uranium, heavy water, beryllium, and cermets are described.

THE TECHNOLOGY OF PRINTED CIRCUITS. By Paul Eisler. Academic Press, Inc., 111 Fifth Ave., New York 3, N. Y., 1959. 405 pages, 5½ by 8¾ inches, bound. $12. Beginning with an account of the invention and development of printed circuits techniques, the author provides a detailed explanation of printed circuit production which includes such aspects as a typical production line, suitable printing methods, plating and foil techniques, protective coatings, flow and dip soldering, and potting. In addition, details are provided for the design of printed circuits, the inserting of conventional components into the printed circuit, and the detection and tracing of faults. Recent developments examined encompass automatic assembly, miniaturization, printed components, and microwave printed circuits.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

NATIONAL BUREAU OF STANDARDS PUBLICATION. On July 1, 1959, the National Bureau of Standards began publishing its *Journal of Research* in four separate sections, corresponding to subject-matter fields, which may be subscribed for individually. This change was made to permit more effective dissemination of the Bureau's findings to science and industry. At the same time, the editorial scope of the *Journal* was broadened to cover the Bureau's technical program as completely as possible. Other current publications changes include the initiation of two new nonperiodical publication series.

The *Journal* is now divided into the following sections, each available upon subscription from the U. S. Government Printing Office, Washington 25, D. C.: Physics and Chemistry, issued six times a year at $4 annually ($4.75 foreign); Mathematics and Mathematical Physics, issued quarterly at $2.25 annually ($2.75 foreign); Engineering and Instrumentation, issued quarterly at $2.25 annually ($2.75 foreign); and Radio Propagation, issued six times a year at $4 annually ($4.75 foreign).

Two of the Bureau's nonperiodical series—*Circulars* and *Building Materials and Structures Reports*—have been discontinued inasmuch as much of the material which appeared in these series now appears in the new, expanded *Journal of Research*. The two newly inaugurated nonperiodical series are: *Monographs* and *Technical Notes*. No change is contemplated in the Bureau's three other nonperiodical series *(Applied Mathematics Series, Handbooks,* and *Miscellaneous Publications)* nor in the other NBS periodicals *(Technical News Bulletin* and *Basic Radio Propagation Predictions)*.

Monographs will consist of major contributions to the technical literature which are too long for publication in the *Journal of Research*. They will comprise much of the type of material that is now published in the larger circulars such as, for example, *Atomic Energy Levels, Tables of Thermal Properties of Gases,* and *Worldwide Occurrence of Sporadic E.*

Technical Notes have been designed to supplement the Bureau's regular publications program. They will provide a means for making available communications and reports that are of transitory or limited interest. *Technical Notes* will be offered for sale by the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. All other NBS publications are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

NEMA STANDARD. *Electrochemical Processing Semiconductor Rectifier Equipments*, RI 6-1959, encompasses conversion equipment utilizing semiconductor rectifying devices complete with the necessary transformer and essential control and protective apparatus, used as a d-c power supply for electrochemical processes. It covers definitions and general standards of service, design, performance, and operation to be used as a basis for the manufacture and use of the equipment. The Standard may be purchased at 60¢ per copy from NEMA, 155 E. 44th St., New York 17, N. Y.

RECENT ADVANCES IN ATMOSPHERIC ELECTRICITY. This 646-page volume, sponsored by the Geophysics Research Directorate, Air Force Cambridge Research Center, contains the Proceedings of the Second Conference in New Hampshire, 1958. The book describes current experimental and theoretical investigations into the many natural electrical phenomena in the atmosphere. The papers are by leading international specialists in this field, and the discussions that followed them are summarized. The book is divided into three major parts: (1) Fair Weather Electricity, (2) Thunderstorm Electricity, and (3) The Lightning Discharge, and contains both an author and subject index as well. The illustrated book, edited by L. G. Smith, is available from Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., at $17.50.

1959 NATIONAL ELECTRICAL CODE. The 1959 Code, published by the National Fire Protection Association (NFPA), is a complete revision of the previous edition issued in 1956, and contains 528 pages. It incorporates a substantial number of important new electrical safety provisions adopted at the recent NFPA annual meeting. An important change is a completely new system of numbering sections and paragraphs. Hereafter, references to the Code will use the new numbers. The new edition includes a cross-reference index to the previous numbering used in the 1956 Code. Copies of the Code, NFPA No. 70, may be ordered at $1 per copy from NFPA, 60 Batterymarch St., Boston 10, Mass.

ELECTRIC POWER FROM THE ATOM. This 32-page booklet tells how America's electric light and power companies are advancing in the field of atomic energy. Included in the booklet, which is the second revision of one issued originally in 1956, is a 4-page listing of the electric companies participating in atomic power projects, and a map showing the locations of all 30 programs under way in the country. There is also a comprehensive 2-page tabulation of details about all of the construction projects, including the types of reactors involved, the electrical capacities of the plants and their locations, estimated costs to both the participating organizations and the U. S. Atomic Energy Commission, and estimated operating dates. Designated EEI Publication No. 59-190, the booklet may be ordered in quantity from the Edison Electric Institute, 750 Third Ave., New York 17, N. Y., at the following prices per copy: 1-99 at 25¢ postpaid in USA; 100-999 (to one address) at 12¢ shipped collect; 1,000-9,999 (to one address) at 10¢ shipped collect; and 10,000 or more (to one address) at 8¢ shipped collect.

AMERICAN STANDARDS. *American Standard Requirements for Solid Dielectric Transmission Lines*, C83.21-1958 (EIA RS-199), covers dielectric cable of the kind used in radio and television transmitting equipment, and is available from ASA Dept. PR 92 at $1.20 a copy. A revision of *American Standard Practices and Requirements for Pool-Cathode Mercury-Arc Power Converters*, C34.1, has been approved by the ASA and published by AIEE. It may be ordered from Dept. PR 88, at $1.40 a copy. A newly revised edition of *American Standard Schedules of Preferred Ratings for Power Circuit Breakers*, C37.6-1959, is available at 40¢ a copy from Dept. PR 85. *American Standard Specification for Shockproof Cable Terminals and Receptacles for Use on X-Ray Equipment*, C86.1-1958, may be ordered at 35¢ a copy from Dept. PR 91. The American Standards Association is at 70 E. 45th St., New York 17, N. Y.

LABORATORY ACTIVITIES WITH LIGHT. A new educational publication of the Illuminating Engineering Society (IES), this 42-page booklet replaces the former "Experiments with Light." The book was prepared to assist students in secondary schools in learning about this branch of the physical sciences and its importance in everyday activities. The text is supplemented by detailed descriptions of 12 classroom demonstrations and activities to be performed by the student himself. Copies may be ordered from Publications Office, IES, 1860 Broadway, New York 23, N. Y., at $1 per single copy up to 9; 10-99 copies, 90¢ each; and 100 or more, 75¢ apiece.

SYMPOSIUM ON CLEANING OF ELECTRONIC DEVICE COMPONENTS AND MATERIALS. Published by the American Society for Testing Materials (ASTM), the report of this symposium presents many aspects of the current knowledge concerning decontamination of electron devices, including both semiconductors and tubes. The book, STP 246, is well illustrated, and may be ordered from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at $6.50 each.

OTS REPORTS. The Office of Techuical Services (OTS) has made the following reports available: technical papers and discussions of the "Sixth Hot Laboratories and Equipment Conference," *TID-7556*, conducted by the U. S. Atomic Energy Commission on problems, achievements, and recommendations concerning the operation and design of such units, Apr. 1959, 172 pages, $1.75; a 1959 revision of the "Catalog of Technical Reports—Transistors," *CTR-310*, 10¢; "A Multifield Electronic Tachistoscope," *PB 151689*, Wright Air Development Center, U. S. Air Force, Dec. 1958, 11 pages, 50¢, which describes a device that has variable duration, sequence, and intensity controls; the final report in the "Dielectric Materials Moisture Resistance Study," *PB 151014*, The Johns Hopkins University for Bureau of Ships, U. S. Navy, March 1955, 76 pages, $2; and a description of a portable, versatile, and inexpensive transistor test set designed by U. S. Army Signal Corps researchers, *PB 151300*, "A Simple Transistor Test Set," Aug. 1957, 8 pages, 50¢. All of the foregoing reports may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C.

U. S. GOVERNMENT PAMPHLETS. Six publications, concerning the electrical/electronic field, have been made available by the U. S. Government Printing Office. The publications, which may be ordered from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., are: *Description of Units, Specifications, and Drawings for Transmission Voltages Line Construction*, REA Form 805, Catalog No. A 68.2:C76/7/959, 55¢; *Brush Control Practices for R/W Maintenance*, Catalog No. A 68.3:161-17, 441-2, 35¢; *Basic Theory and Application of Transistors*, Catalog No. D 101.11:11-690, $1.25; *On the Theory of Fading Properties of a Fluctuating Signal Imposed on a Constant Signal*, Catalog No. C 13.4:599, 25¢; *Dielectric Constant and Electrical Resistivity of Natural-State Cores*, Catalog No. I 19.3:1052-11, 20¢; and *Use of Electronic Data-Processing Equipment*, Catalog No. Y 4.P 84/10:El 2, 40¢.

TOOLS FOR MACHINE LITERATURE SEARCHING. By J. W. Perry and Allen Kent of the Center for Documentation and Communication Research, Western Reserve University, Cleveland, Ohio, this first volume in a new series is in four major sections: (1) Introduction to Machine Literature Searching Systems, (2) Engineering of Machine Literature Searching Systems, (3) Procedures for Analyzing, Encoding, and Searching of Recorded Information, and (4) A Thesaurus of Scientific and Technical Terms: The Semantic Code Dictionary. Containing 922 pages, and illustrated, the book is published, at $27.50, by Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y.

THE HUMAN FACTOR in today's technology

Scientists have long been preoccupied with the technological problems of Man and the Machine. The increasingly complex nature of advanced systems has created an urgent need to enhance man's contribution to effective systems performance. The complicated nature of this relationship requires the skills of psychologists, social scientists, mathematicians, and engineers.

At Ramo-Wooldridge, human engineering, personnel selection, individual and system training, display design, and communications are successfully integrated into systems design and development by the technique of large-scale simulation.

Simulated inputs enable scientists to observe a system as it operates in a controlled environment and make possible the collection of data on performance, training, human engineering, maintenance, and logistics and support. Scientists and engineers use this data to assure the design, production, and delivery of a unified system capable of high performance and reliability.

Expanding programs at Ramo-Wooldridge in the broad areas of electronic systems technology, computers, and data processing have created outstanding opportunities for scientists and engineers. *For further information concerning these opportunities write to* **Mr. D. L. Pyke.**

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P. O. BOX 90534, AIRPORT STATION • LOS ANGELES 45, CALIFORNIA
a division of *Thompson Ramo Wooldridge Inc.*

New and Improved Products . . .

Door Interlock Switch . . .

A subminiature single-pole double-throw switch designed for high-voltage cabinets and radio, radar, sonar, X-ray, and other electronic cabinets automatically cuts off power when the cabinet service door is opened. By pulling the plunger to the maintained contact position, it is possible to check circuits with the power on. The plunger automatically returns to the normal operating position when the door is closed, eliminating the dangers of wiring around conventional switches. **Micro Switch, Freeport, Ill., a division of Minneapolis-Honeywell Regulator Co.**

Radar Display Tube . . .

A new tube known as developmental type *C-73959* has approximately twice the resolution capability of currently available display storage tubes. When used as a radar indicator, the tube can distinguish between two closely spaced targets where other storage tubes would often make two such targets appear as one object. This latest development is capable of resolving more than 800 television lines per display diameter of 3.8 inches when operated at a display or picture brightness of approximately 100 foot-lamberts. **Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.**

Vertical Sensor . . .

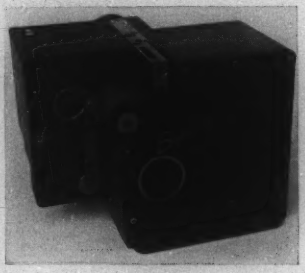
A sensitive electrical plumb-bob weighing only 2½ ounces is the newest instrument used to check a missile's vertical position on its launching pad. The sensor consists of an iron pendulum suspended in a small tube 5 inches long filled with a damping fluid. Miniature coils spaced 90 degrees apart at the bottom of the tube form magnetic pickups which detect any deviation of the pendulum from center position. When excitation is applied, the pickups produce an output which increases linearly as the unit tilts from the vertical. When the tube is exactly upright, the unit is at electrical null. **Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N. J.**

Power Factor Capacitors . . .

Entry into this field follows 5 years of design and development work. These components are available in two sizes, 25 and 50 kvar and 2,400 through 7,960 volts. They are built to rigid specifications utilizing high quality, low loss materials, foil cooling, and extra low drying and degasification pressures. Included in the capacitor package are pole-type racks, stacked racks, voltage sensitive controls, voltage sensitive current compensating controls, current sensitive controls, switches, fuses, and other accessories. **Allis-Chalmers Manufacturing Co., Milwaukee 1, Wis.**

Super-Speed Tape Perforator . . .

The *GP2* can punch up to 300 coded characters per second in standard communications paper or Mylar tape at a speed said to be many times faster than other previously available tape perforators. The basic recording cycle allots one-third of a cycle to tape transport and two-thirds to punch pin pentration of the tape.



At 300 cps, one complete punching and feed cycle is executed in about 3 1/3 milliseconds. The entire unit is no larger than a standard press camera and is available for perforating 5, 6, 7, or 8 hole tapes. **Soroban Engineering, Inc., Melbourne, Fla.**

Silicon Readout Photocells . . .

Designed specifically for computer and data-processing equipment where rapid detection of light passing through punched cards or tape is required, these silicon photovoltaic readout matrices feature extremely fast response time in the order of 10 microseconds. Each matrix is made up of a multiple array of individually segmented silicon cells. Light energy striking a particular segment will cause power to flow from that segment only. Typical current generated is 300 microamperes for 0.01 square inch of active cell area at 1,000 foot candles illumination. **International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.**

Automatic Voltage Regulators . . .

Two new fully transistorized electromechanical automatic voltage regulators are available for applications where loads up to 8.4 kva must be controlled by a relatively small sized assembly. Both types are designed for either 120 or 240 volt, 50/60 cycle, single-phase duty. For a nominal output of 120 volts the input range is 108-137 volts and maximum output is 35 amperes, 4.2 kva. For a nominal output of 240 volts the input range is 228-256 volts and maximum output is 35 amperes, 8.4 kva. Other characteristics are zero wave form distortion, very low internal impedance, virtually zero phase shift, efficiency of better than 98%, high accuracy, and extreme reliability. **The Superior Electric Co., Dept. 4104, Bristol, Conn.**

Electric Snow Melter . . .

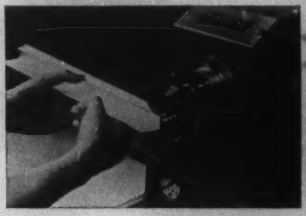
A fast, low-cost method of installing a radiant heating system beneath concrete walks or driveways for electric snow removal employs preassembled mesh and wire mats that are simply rolled into place. The new packaged product employs prespaced thermoplastic-insulated resistance wire anchored to the galvanized steel mesh. Each unit is 10 feet long and 18 inches wide. The wire mesh not only protects the heater wire, but also adds extra reinforcement to the concrete. **Easy-Heat, Inc., Lakeville, Ind.**

Open-Side Thimble Clevis . . .

A simplified, efficient method of making corner or dead-end conductor attachments is provided by the 674 open-side thimble clevis. The conductor is simply looped around the wire groove eliminating the need for threading through the clevis. The deep groove, which makes almost a complete circle, assures a secure grip. The thimble is 2¼ inches in diameter and will accommodate strand or wire ¾ inch or under. **Hubbard and Co., 200 S. Michigan Ave., Chicago 4, Ill.**

Ultrasonic Seam Welder . . .

Light gauge aluminum sheets can now be welded at speeds in excess of 30 feet per minute with the Sonoweld ultrasonic roller welder. Conservative estimates indicate this rate will be doubled in the near future. Unlike induction or resistance welding



Courtesy Alcoa

that involves melting, ultrasonic seam welds can be stopped and started abruptly without producing long "start-up" seam sections of inferior quality. This process holds special promise for container and packaging manufacturers. **Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa.**

(Continued on page 20A)

Popular, small Model VT2 (with overvoltage). Volts output: 0-120/132; amps output: 1.5 . . . Model VT2N (without overvoltage). Volts output: 0-120; amps output: 1.8. This model delivers more current than existing transformers of comparable size and price.

Models VT4 and VT4N provide output capacity greater than other units of comparable size and price. Model VT4 (with overvoltage). Volts output: 0-120/140; amps output 3.5 . . . Model VT4N (without overvoltage). Volts output: 0-120; amps output: 4.75.

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VARIABLE TRANSFORMERS

Complete Line Now Available from Stock

Models VT8 and VT8N offer the heavy capacity demanded for general laboratory and industrial applications. Model VT8 (with overvoltage). Volts output: 0-120/140; amps output: 7.5 . . . Model VT8N (without overvoltage). Volts output: 0-120; amps output 10.0. Units available for 240-volt input also.

Now you can get *fast delivery from stock* on 35 different models of Ohmite variable transformers. This newly expanded selection covers a high percentage of industrial needs. In it you will find single and three-phase units, two and three-in-tandem assemblies (not shown above), plus a variety of other cased and uncased models.

Ohmite "v.t." variable transformers combine fresh thinking in design with traditional Ohmite quality. For example, positive current transfer is achieved with direct brush to slip-ring, pig-tailed connection. Adjustable shafts on sizes VT4 and VT8 extend either to the brush or the base side. These two models also are *interchangeable* with competitive makes of comparable ratings. The "N" types in all three models provide additional current without overvoltage. The next time you need variable transformers, select from the line with advanced design—Ohmite.

Write for NEW Stock Catalog 30.

OHMITE® QUALITY Components

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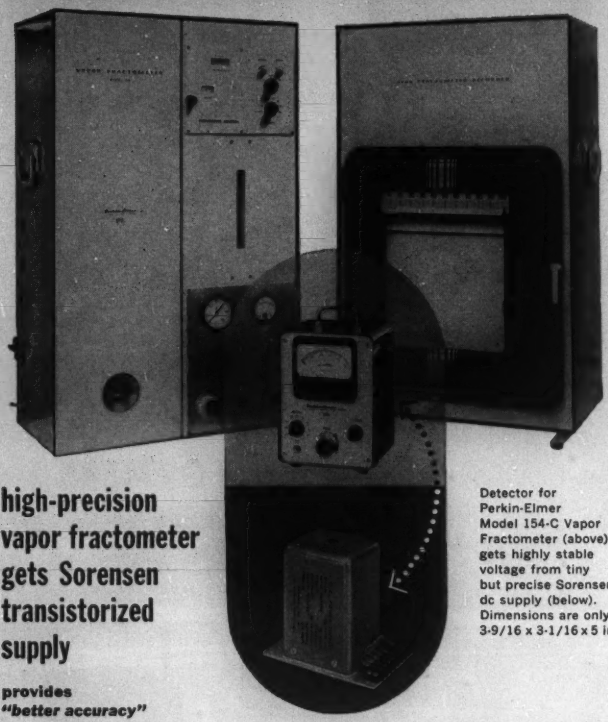
RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS DIODES
VARIABLE TRANSFORMERS R. F. CHOKES

NEW IDEAS IN PACKAGED POWER

for lab, production test, test maintenance, or as a component or subsystem in your own products



high-precision vapor fractometer gets Sorensen transistorized supply

provides "better accuracy" says Perkin-Elmer

Detector for Perkin-Elmer Model 154-C Vapor Fractometer (above) gets highly stable voltage from tiny but precise Sorensen dc supply (below). Dimensions are only 3-9/16 x 3-1/16 x 5 in.

Perkin-Elmer Corporation, Norwalk, Connecticut, selected a modified Sorensen miniature transistorized supply to build into the hot-wire detector unit for their new precision Model 154-C Vapor Fractometer.

They report they're pleased with the speed with which Sorensen modified their standard Model QM miniature voltage-regulated dc supply to fit their specialized requirements and they praised Sorensen's quick deliveries. But here's the statement we, at Sorensen, liked best:

The QM ". . . appears to afford even better regulation than Sorensen's specifications show (better than ±0.05% variation in output voltage for a 10% change in line voltage)." Need we say more?

Sorensen makes the widest line of transistorized power supply equipment on the market today—plus a complete line of electronic and magnetic-amplifier regulators for ac and dc, inverters, converters, and frequency changers, plus a complete line of extremely high-voltage equipment. Write for catalogs. And if you have a special problem or tough specifications to meet, ask the advice of your nearest Sorensen representative—he'll have the answer. 8.48

SORENSEN & COMPANY, INC.

Richards Avenue, South Norwalk, Connecticut

WIDEST LINE OF CONTROLLED-POWER EQUIPMENT FOR RESEARCH AND INDUSTRY

IN EUROPE, contact Sorensen-Ardag, Zurich, Switzerland. IN WESTERN CANADA, ARVA. IN EASTERN CANADA, Bayly Engineering, Ltd. IN MEXICO, Electro Labs, S. A., Mexico City.

NEREM '59 Commonwealth Armory, Boston Nov. 17, 18 & 19

New & Improved Products

(Continued from page 18A)

Radiated Interference-Free Lighting Panels . . .

A glass lighting panel that eliminates radio interference radiated by fluorescent lamps has been introduced for use in research laboratories and hospitals using electrocardiographs, electroencephalographs, hearing test equipment, and brain-wave detection apparatus. The panels also can be used in radio stores, and in schools for the deaf where radiation affects amplification apparatus. The product consists of a low brightness lens panel coated on one side with a thin, transparent electrically conductive film. The coating intercepts the radiated interference which is grounded by a ¼-inch wide silver strip fired onto the film around the periphery of the glass. **Corning Glass Works, Corning, N. Y.**

Open-Wire and Cable Carrier . . .

The *B-630* represents an entirely new, short-haul carrier telephone system that provides up to 12 toll-quality voice circuits between 40 and 416 kcs. Available as part of the system is a broad-band, fully transistorized amplifier designed as a one-way cable repeater. Versatility is achieved by using separate packaging of transmitters and receivers in individual plug-in chassis. **Lynch Carrier Systems, Inc., 695 Bryant St., San Francisco 7, Calif.**

Infrared Generators . . .

Smaller, less costly ovens for many industrial drying and baking operations can now be used with these 1-kw infrared heat generators. Similar to the lower wattage driQuick generators, this new addition to the line has no rods, bulbs, quartz tubes, or sockets to burn out. Varying temperatures in different sections of the oven can be attained by using cyclical controllers for different heat finish requirements. **Dry Clime Lamp Corp., Greensburg, Ind.**

Closed-Circuit Television System . . .

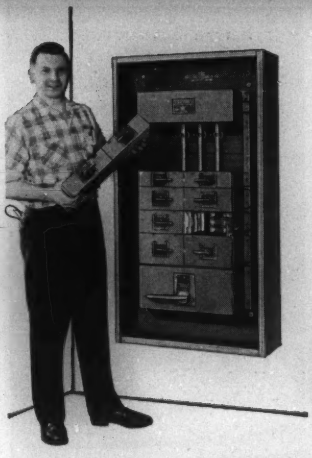
Introduction of a complete line of equipment marks this company's entrance into the closed-circuit television field. The four types of general-purpose industrial cameras and one viewfinder studio camera are highly sensitive, stable instruments providing 550-600 line horizontal resolution. The former provide either random interlace or locked interlace and either automatic light compensation or manually controlled compensation. Extremely fine vertical resolution is achieved with the interlocked model through use of a binary counter. **Motorola Inc., 4501 W. Augusta Blvd., Chicago 51, Ill.**

(Continued on page 22A)

EXACTLY THE PANELBOARD YOU WANT

Right Off Your Square D Distributor's Shelf!

In our contracting business, we find QMB PANELBOARDS are just the thing for heavy industrial jobs. The switches are heavy-duty horsepower rated and they plug in just like plug-in duct units or drawout air circuit breakers. The switch unit I'm holding is a twin 60 ampere 3-pole unit, rated 600 volts. We picked up the entire panelboard this morning from our local Square D distributor's stock to use on a 480 volt job. *We'll have it installed and wired by tomorrow afternoon—and no overtime.*



Notice that this 240 volt switch is much smaller than the 600 volt unit. That means we can put more circuits in the same size panelboard. Since Square D started making these new smaller units, we've been using QMB on all our commercial jobs. The interiors and boxes are the same for both 240 and 600 volt panelboards. That means one stock can work for both. *We can get the complete panelboard from our local Square D distributor the same day the job develops.*

We don't gang separate safety switches and motor starters over a trough any more. The new QMB MOTOR STARTER PANELBOARD makes a much cleaner job. It's easier to install, it costs no more, and it's in our distributor's stock. In our business, we're concerned with overall installed costs. We find the installed cost of the QMB STARTER PANELBOARD is no greater than that of separate components. The interlock between the switch and starter doors makes a much safer installation, too.

• Plug-in construction combined with heavy-duty industrial design has made the QMB PANELBOARD a tremendous success. In fact, the flexibility of this unit plus availability from distributor stocks, has made it the leading power panelboard on the market. It's available either in 600 volt or 240 volt construction. Motor control units are available for use with either voltage switch units. When switch units exceed 200 amperes, the panelboards can be obtained from the nearest Square D Assembly Plant, completely factory-assembled. It's the modern fusible standard.

For additional information
write Square D Company, 6060 Rivard Street, Detroit 11, Michigan

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

for dependable, static, economical,
high gain, microseconds switching of peak power

XENON THYRATRONS excel

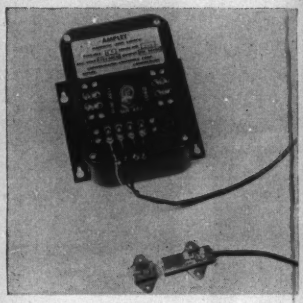
ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.

New & Improved Products

(Continued from page 20A)

Magnetic Limit Switch . . .

A limit switch with no moving parts, that acts on proximity of two sensing elements rather than actual physical contact, is ideally suited to automation where precise control of the relative motion between two parts of a machine is required. Typical uses include limiting cuts or traverse on machine tools, stopping conveyors at predetermined positions, continuous sequencing and counting, and automatic



weighing and filling. The device consists of a probe, normally mounted on a stationary part of the machine being controlled, a magnetic trigger, which is mounted on a moving part of the machine or part being machined, and a power amplifier, which increases the power output of the probe to useful levels. **Consolidated Controls Corp., Bethel, Conn.**

Short Circuit-Proof Power Supply . . .

Model *ME 36-5M* power supply has no external circuit breaker handle and no fuses, yet is virtually short circuit-proof. This is accomplished by a fast-acting relay that energizes an internal circuit breaker when the current reaches a preset value. The supply operates from a source of 95- to 125-volt 60-cycle power regulated to $\pm$ 0.5%. **Mid-eastern Electronics, Inc., 32 Commerce St., Springfield, N. J.**

Microwave Stability Tester . . .

Offering unusual accuracy, the Series 800 Stalo Tester measures long-term drift and short-term deviation in frequency bands between 1,100 mc to 10,000 mc. Its primary purpose is to check the stability of radar systems components such as stalos, cohos, klystrons, and other stable signal sources. Other applications include troubleshooting of moving target indicator radar systems, isolating sources of frequency disturbance, maser and parametric amplifier evaluation, and radio astronomy. **Pitometer Log Corp., 237 Lafayette St., New York 12, N. Y.**

(Continued on page 24A)

NEW!

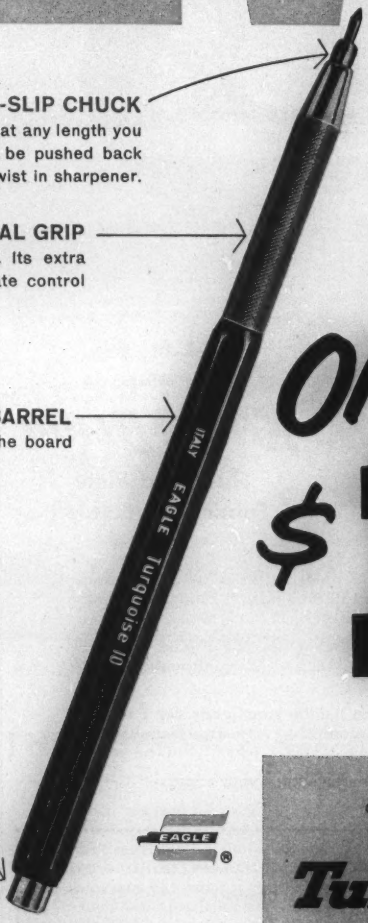
This Eagle Turquoise Lifetime 1 lead holder with all these extra features . . .

NEW NON-SLIP CHUCK
holds lead firmly at any length you want. Lead can't be pushed back in barrel, won't twist in sharpener.

NEW SATIN FINISH METAL GRIP
is knurled for easier holding. Its extra length gives you more accurate control with less finger tension.

NEW ANODIZED ALUMINUM BARREL
is unbreakable. And it can't roll off the board because it's hexagon-shaped.

NEW PUSH BUTTON
instantly releases the chuck's grip on the lead at the touch of the thumb. It's colored for quick identification of grade.



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SEE the extensive facilities and equipment of Kirk & Blum's 170,000 sq. ft. plant . . . for steel and alloy fabrications up to 25 tons.

SEE how Kirk & Blum can handle your needs, for 1 or 1000 units, economically and promptly, with traditionally high K & B quality.

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Firm_____

Address_____

City_____ Zone____ State_____

New & Improved Products

(Continued from page 22A)

Pencilled Graph Programmer . . .

Called the Prekorder, this instrument, resembling a conventional circular and strip-chart recorder, can follow a pencil-drawn chart to control a system or process and simultaneously superimpose a performance record on the same chart. The program appears as a double line pencilled directly on the chart. These lines are electrically connected to a center-tapped transformer which serves as a voltage source for an electrostatic field between the two lines. The recording pen acts as a capacitance probe picking up an error signal proportional to any deviation of the pen from its null position midway between the pencilled lines. Temperature, pressure, voltage, liquid level humidity, speed, and other factors can be readily programmed to follow a set course. **Research, Inc., 115 N. Buchanan St., Hopkins, Minn.**

Small Indicator Lamp . . .

Drawing under 50 ma at 1.3 volts, this newly designed microminiature incandescent indicator lamp operates directly from the output of a transistor without amplification. It is precision-built for trouble-free application in computers and a wide variety of military electronic devices where size and low current draw are important. **Minitron Components Corp., 67 Illinois Ave., Paterson, N. J.**

Liquid Level Measure Device . . .

Ultrasonics are used in this instrument for precise measurement of liquids such as slurries, thick oils, fused salts, molten metal, liquid nitrogen, and other fluids. Output is either digital or continuous and adaptable to recording and control, porportioning, and blending. This method uses solid metal acoustic waveguides to derive its information, thereby ignoring or cancelling the effect of the liquid's properties on the accuracy of level measurement. **General Ultrasonics Co., a division of Acoustica Associates, Inc., 6 Tobey Rd., Bloomfield, Conn.**

Panelescent Night Light . . .

An application of electroluminescence will soon be marketed in the form of a night light. Only 0.025 of an inch thick and 3¼ inches in diameter, the light is provided with plug-in prongs for insertion into any standard wall receptacle. A porcelainized steel sheet with a ceramic-phosphor coating takes the place of bulbs, tubes, filaments, and cathodes. Another feature is that the night light may be operated day and night for five years at a cost of 3¢ or less per year for electricity. **Sylvania Electric Products Inc., a subsidiary of General Telephone & Electronics, 730 Third Ave., New York 17, N. Y.**

(Continued on page 26A)

FOR ALL-WEATHER SERVICE *Specify Kerite Cable*

The arithmetic of self-supporting aerial cable can never, unfortunately, ignore the weather nor Nature's way of making trees grow where overhead lines would rather be.

Moral: When you decide to invest in the protection of insulated aerial cable, make sure that it's there to stay, to resist the elements until long after the installation has paid for itself.

Check back on your own company's records of aerial cable performance and you'll probably find—as have progressive companies the country over—that dependable Kerite insulation lasts longer, and pays its way better.

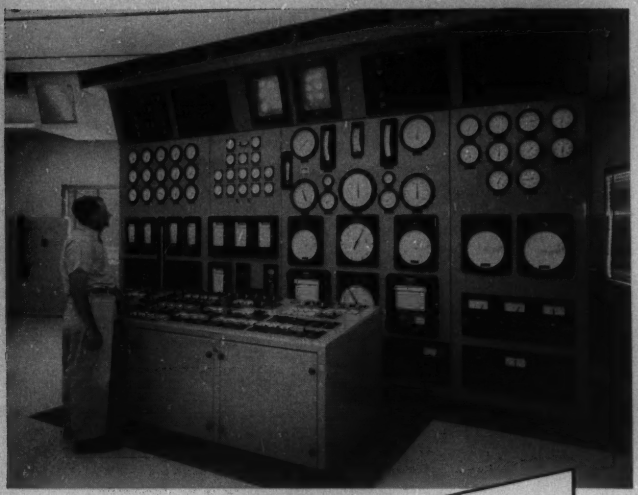
The arithmetic of aerial cable—so fundamental, so simple.

KERITE CABLE

it's the **KERITE** *that makes the difference*

Our headquarters is at 30 Church St., New York 7.

BRANCHES IN
Ardmore, Pa., Birmingham, Boston, Cleveland, Chicago, Houston, Portland, Ore., St. Louis, San Francisco, Glendale, Cal., Seattle

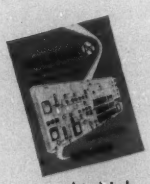


Everything including . . . TV

The Nelson Control Panels used at Michoud Steam Electric Generating Station of New Orleans Public Service Inc., include two closed circuit-television screens at the top of the boiler-turbine-generator control boards for monitoring the burners.

These control panels are used at Michoud Steam Electric Generating Station for controlling the operation of a 144,000 kva generator, 975,000 lbs. hr., 1550 psi boiler and associated equipment. Note the smallness and compactness of the console. By using lever controls and instrument lights on removable plates, a much smaller console was made possible.

When you have a job to do, big or small, and you need instrument or control panels, be sure to call Nelson.



Write for Bulletin 712. This new bulletin tells about Nelson control boards and instrument panels.

At Nelson . . . *quality* comes first!

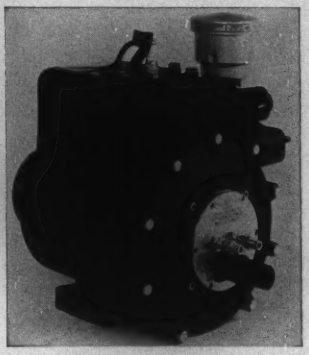
NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

New & Improved Products

(Continued from page 24A)

High-Frequency Kw Alternator . . .

Driven by a 2-hp gasoline engine, this 1-kw self-contained power supply will provide 2,500 volts at 0.4 amperes and 2,000 cycles per second without using step-up transformers. The unit is designed specifically as a field power supply for single-sideband transmitters, but can also be



adapted for powering geophysical exploration equipment, Signal Corps field transmitters, and for communications or electronic equipment used by field crews in road building, oil drilling, mining, lumbering, etc. **Dalmotor Division, Yuba Consolidated Industries, Inc., 351 California St., San Francisco 4, Calif.**

Continuity and Leakage Tester . . .

This tester has been designed for use by electrical workers, repairmen, laboratory technicians, and wherever an extremely wide-range continuity and leakage tester is required. Where other testers use a lamp or buzzer and have a tendency to fail in circuits that exceed 30 to 50 ohms resistance, the Audiotone produces an audible sound proportional to the value of the electrical resistance of the circuit being tested. The instrument requires no visual observation and has a range from 0 to 100 megohms. **Peschel Electronics, Inc., RFD #1, Paterson, N. J.**

Silicon Rectifier . . .

Designed as a direct replacement for the *866* mercury vapor rectifier tube, the *S-5130* silicon rectifier is capable of continuous duty operation of 300 ma d-c at 10,400 PIV with a resistive-inductive load. Smaller than the 866 tube, it requires no filament power or warm-up period. Shock hazard is minimized by use of an impregnated housing. **Sarkes Tarzian, Inc., Rectifier Division, 415 N. College Ave., Bloomington, Ind.**

(Continued on page 32A)

erating energy and more compact construction. Faster response will be limited only by the time required for integration (the thinking and command function).

Protective relaying took a long stride forward with the development of this new Westinghouse 3-phase relay for generator protection.

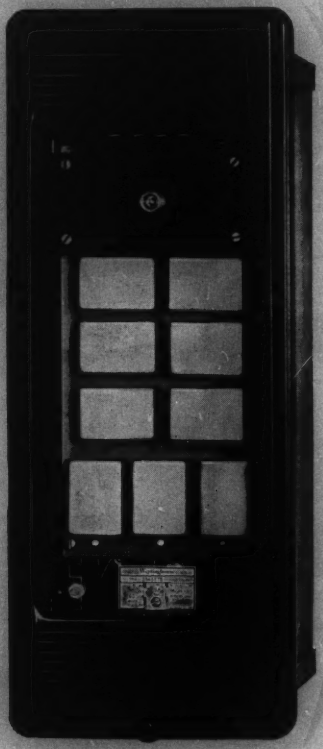
Call your Westinghouse sales engineer to get the story on our work in the field of statics and protective relaying. J-40527

YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

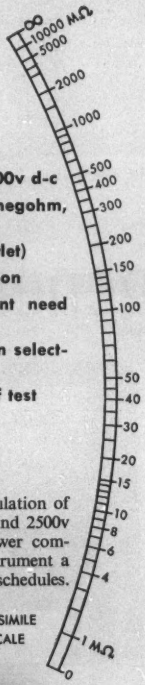
ANNOUNCES THE SA

differential generator relay



New MEGGER®
INSULATION TESTER

. . . 6-Voltages
. . . Rectifier Operated



FACSIMILE SCALE

FEATURES

- 6 output voltages 500, 750, 1000, 1500, 2000, 2500v d-c
- single scale, wide resistance range 0-10,000 megohm, easy to read
- rectifier-operated (plug-in to standard lighting outlet)
- excellent output voltage stabilization and regulation
- extremely rugged measuring system—instrument need not be leveled, fast indication
- single output voltage selector switch—no errors in selecting test voltage
- automatic discharge of tested insulation at end of test
- easily portable, moderate size and weight

APPLICATION

Ideal for making step-voltage resistance tests on the insulation of electrical equipment with voltage ratings in the 300, 600 and 2500v classes. Maintenance men in large industrial plants, power companies and railroad electrical repair shops find this instrument a real time saver where many tests must be made on tight schedules.

Write for BULLETIN 21-20a-EE

B 905

JAMES G. BIDDLE CO.
Electrical Testing Instruments • Speed Measuring Instruments
Laboratory & Scientific Equipment
1316 ARCH STREET, PHILADELPHIA 7, PA.

New & Improved Products

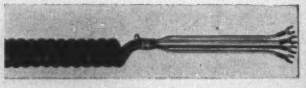
(Continued from page 26A)

Supersensitive Overload-Proof Meter . . .

This meter is said to have an overload capacity of 125 million per cent and yet have a sensitivity down to 0.2 microamperes. This is achieved by a design that incorporates a frictionless two-threaded movement combined with a light-beam pointer. A moving coil is suspended by twin pairs of taut parallel wires and is free to turn within the magnetic field. When no current flows, the wires remain parallel. The moment current flows, it causes the coil to rotate. A tiny mirror on the coil reflects an illuminated hairline on a calibrated scale. In this way, the usual jewels, pivots, and hairsprings with their drag and jamming effect are eliminated. **Greibach Instruments Corp., 315 North Ave., New Rochelle, N. Y.**

Trouble-Free Coiled Cords . . .

A self-retracting coiled cord capable of withstanding excessive extension and retraction over long periods of service prevents the conductors from twisting or kinking inside the outer jacket. This feature



eliminates abrasive action and noise during coiling and uncoiling. Laboratory use-tests show that P-M Coiled Cords with tinsel conductors can be coil-extended more than 500,000 times with no appreciable noise-level increase or physical damage to the cord. **Patton-MacGuyer Co., 17 Virginia Ave., Providence 5, R.I.**

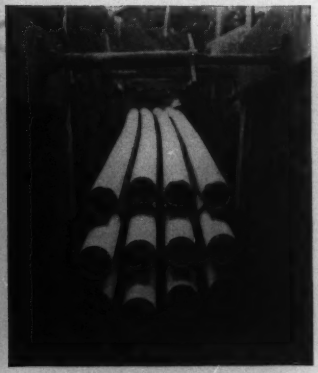
Civilian Radiation Detector . . .

A low cost, pocket-sized, radioactive fallout detector and alarm has been designed to give protection in the event of nuclear attack. The new device, called FIDO (Fallout Intensity Detector Oscillator), emits an audible signal that increases in intensity as radiation increases above 0.2 rph. **Controls for Radiation, Inc., Cambridge, Mass.**

Get peak cable protection ***at lowest dollar cost***

Transite Ducts can be laid directly in trench without concrete envelope. Or if ductbank is to be concrete enclosed—thinner walled Transite Duct may be used. In all other respects both heavy-wall and thin-wall Transite Ducts are identical.

Transite Ducts save on the job and after!



No other duct material gives you so many installation and in-service economies

In every way, Transite® Ducts are the most efficient electrical ducts you can install. And—when assembled with J-M's Plastic Coupling—their cost is remarkably low!

One reason for this economy is in installation. Strong, lightweight, long—Transite lengths are easy to handle and install . . . Your men set the ducts in place easily, join them tightly in seconds. Transite's smooth bore is free of burrs and obstructions. Thus, long cable pulls are easily accomplished with no damage to cable sheathing.

You see another reason for Transite's economy in performance. Once in service, Transite's unusually high rate of heat dissipation means cables run cooler, last longer. Transite also confines arc damage . . . cannot burn, smoke or fume. It won't generate explosive or toxic gases. If arcing does occur, Transite Ducts won't sag or adhere to cable.

Let us send the Transite Duct brochure EL-29A. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

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SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S QUALITY CONTROL is approved by the A.E.C., leading aircraft and missile manufacturers.

Write For Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.
3410 W. 67th Street
Los Angeles 43, Calif.

Industrial Notes...

Photocircuits Corp.
Glen Cove, N. Y. . .

Drilled quantities of any reasonably sized printed board, one- or two-sided, with a choice of any pattern, hole configuration, plating, or base material, are possible without art-work costs or tooling charges. This cost-reducing advantage is made possible by a sheet of Mylar printed with x and y co-ordinates over a photographically nonreproducible $\frac{1}{10}$ grid matrix. Working with this form, the designer–engineer merely sketches a "true" size diagram of the circuitry he desires. For further information on the master circuit system, write Dept. P-1331, Photocircuits Corp., 31 Sea Cliff Ave., Glen Cove, L. I., N. Y.

Amperex Electronic Corp.
Hicksville, L. I., N. Y. . .

An engineering wing to be added to the Amperex building will add 13,000 square feet of working space to the 100,000 square feet of the present building. Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Collins Radio Co.
Dallas, Texas . . .

The company's News Bureau has moved its headquarters to Box 1891, Dallas 21, Texas. Direct inquiries and correspondence to Manager, News Bureau, Collins Radio Co., at the above address. The Telephone number is ADams 5-4511.

Armco Steel Corp.
Middletown, Ohio . . .

A grade of electrical steel known as Armco Oriented *M-5*, now in production, is reported to offer an improved quality that permits redesign of transformers to a smaller size, or makes possible increased efficiency. Oriented *M-5* will be available with a core loss limit of 0.58 watts per pound when tested under the standard conditions of 15 kilogausses and 60 cycles. The improvement in core loss is almost 10% compared to *M-6*. The new electrical steel is produced in 12-mil thickness and in coils from $\frac{1}{8}$ inch to 31 inches wide.

H. K. Porter Co., Inc.
Chicago, Ill. . .

The Powerupter, a completely enclosed device for mounting on disconnect switches to interrupt currents of 600 amperes and up to 34.5 kv, was subjected to severe ice tests in a freezer chamber simulating crucial field conditions, by Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 Fulton St., Chicago 12, Ill. Mounted on a vertical-break switch, the unit was frozen first in the open and then the closed position under controlled laboratory freezing to obtain a minimum of $\frac{3}{4}$-inch ice accumulation. Then it was operated to check ice-breaking characteristics. Opening and closing of both disconnect and Powerupter was successful

each time. The Powerupter is now available for mounting on any type disconnect presently manufactured by Delta-Star.

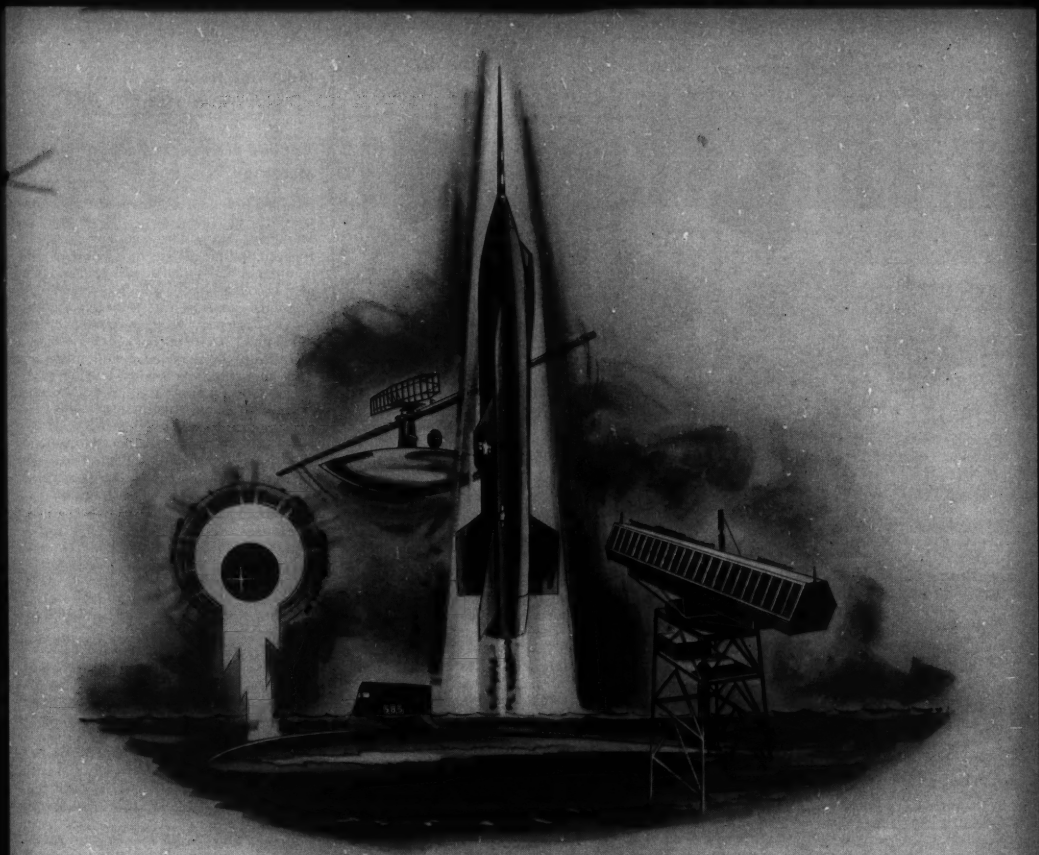
Reeves Sound Studios, Inc.
New York, N. Y. . .

A method of producing television programs on tape, that permits electronic editing or mixing of taped scenes and sounds, was described recently by engineers of the Reeves Sound Studios, Inc., 304 E. 44th St., New York, N. Y., and the Radio Corporation of America. The new concept will permit mixing information on television tape with similar flexibility as on motion-picture film. Because of this, motion picture production techniques can be used in television production. This method of assembling a television production on tape involves the use of prerecorded tapes bearing picture information from any number of cameras, along with the sound tracks. By employing several tape recording and playback machines, with matching monitors, the system will enable the producer and director to see different views simultaneously and choose the most desirable scenes. Then he can schedule the complete program and electronically edit the desired sequences into a master monitor and recorder.

Blaw-Knox Co.
Pittsburgh, Pa. . .

Expansion of transmission facilities by Jersey Central Power and Light Company, Asbury Park, N. J., will require installation of approximately 261 steel towers on the firm's new Larrabee-Mercer line. The line will carry 230-kv, double-circuit wires on towers ranging in height to 208 feet. Designed by Blaw-Knox Co., 300 Sixth Ave., Pittsburgh, Pa., the towers will require use of more than 3,500 tons of steel during fabrication at the firm's Pittsburgh area plant.

(Continued on page 36A)



THE SEARCH . . .

Your attention is invited to a limited number of senior positions created by Raytheon Government Equipment Division's current expansion.

Comprehensive anti-submarine warfare systems
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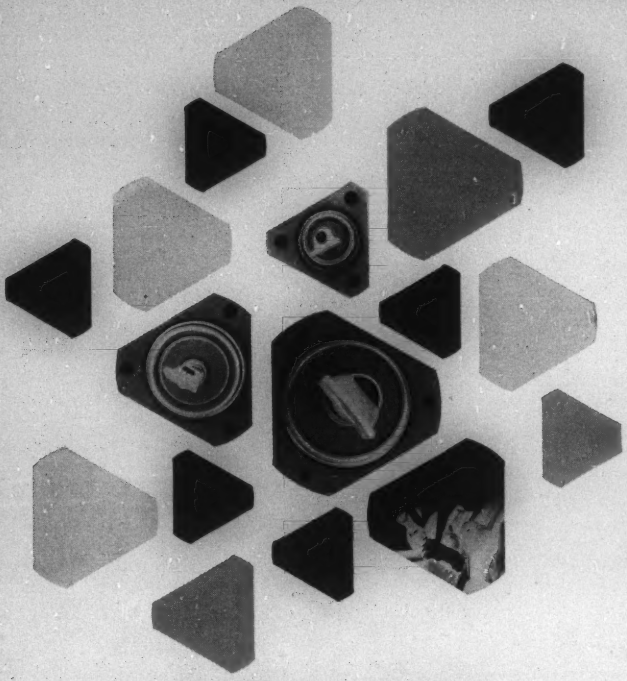
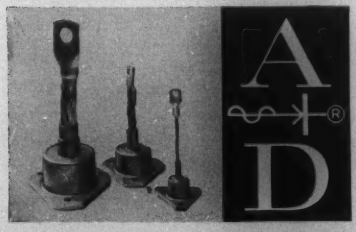


PATTERNS IN POWER

Silicon Rectifiers by Audio Devices establish new standards for high power industrial applications. Available in current ranges of 25 to 250 amperes (nominal, single-phase, half-wave rating), 50-400 PIV, with positive or negative base connections. Hermetically sealed AD Silicon Power Rectifiers provide users with longer life and more efficient operation under high temperature conditions. All units, including ½ amp. and up, now available from stock. For engineering data, write, wire or call RECTIFIER DIVISION, AUDIO DEVICES, INC., 620 E. DYER ROAD, SANTA ANA, CALIF. KImberly 5-8241.

IN CANADA: Alex L. Clark, Ltd., Toronto 18, OVERSEAS EXPORT: ROCKE INTERNATIONAL CORPORATION, New York 16.



Industrial Notes

(Continued from page 34A)

Applied Electronics Corp. of N. J. Metuchen, N. J. . .

The new address of Applied Elcctronics Corp. of New Jersey is 22 Center St., Metuchen, N. J. The company is chiefly engaged in the design, development, and manufacture of missile and ground telemetry systems, and numbers among its personnel some of the pioneers of solid-state telemetery, having developed the solid state PAM telemeter to be flown successfully in a major missile program. The new quarters consist of a 4,000-square-foot plant including a well equipped laboratory with many precision machines and electronic devices, and are located on the main line of the Pennsylvania railroad. Administration, research, development, sales model shop, and production activities are carried out at this location and, in addition to this, the company has approximately 500,000 square feet of industrial park available to it as required.

Waltham Precision Instrument Co. New York, N. Y. . .

A "satellite clock and time programmer," is now being developed by the Waltham Precision Instrument Co., 38 W. 53rd St., New York 19, N. Y., for use in the effort of the United States to put a man into space and bring him back alive. Called a chronometric programmef, the new device will record the elapsed time from the launching of the man-bearing satellite and automatically will set into motion a split-second schedule of 13 important activities, including the re-entry from space to earth. It will also provide signals to be transmitted in a short span of time to monitoring stations on earth. To accomplish these critical requirements, it will be necessary to employ a combination of electromechanical and mechanical devices. A problem will be the adjustment of the satellite clock on earth, where it is subject to the force of gravity, and yet have it operate with absolute accuracy in space where there is no gravity. Entirely new means to achieve zero gravity conditions on the ground must be achieved in order to test the programmer. The testing procedures are of critical importance to assure the reliability of all equipment and assure the safety of the astronaut.

Space Electronics Corp. Glendale, Calif. . .

A new 15,000 square foot facility for research, development, and production in missile-space electronics is located at 930 Air Way, Glendale, Calif. The new building includes executives offices, engineering quarters, development laboratories, and a limited production area. Provision has been made for additional facilities in the near future.

(Continued on page 38A)

PROGRESS IN PLASTICS

NEW PHASE-FAILURE RELAY RELIES ON DI-CLAD® EPOXY-GLASS PRINTED CIRCUIT

Reliability of operation is the prime advantage of using CDF insulating materials. This reliability is amply demonstrated in a new phase-voltage-balance monitoring device produced by CDF customer Phase-Guard Co., and distributed by Stradley Engineering Co.

Phase-Guard, a new phase-voltage-balance monitor built on a CDF Di-Clad 28E epoxy printed circuit.

The Phase-Guard can be used to protect magnetically-controlled three-phase equipment that would be damaged if subjected to abnormal phase conditions such as single-phasing. In conjunction with a normally closed relay supplied from an external power source, it can even be used to monitor any three-phase supply line and sound an alarm when phase-failure occurs. Since this is a voltage-sensing device and only sensory and control-circuit wiring is required, Phase-Guard needs no costly series load connections.

The printed-wiring board which forms the foundation of the Phase-Guard relay is made from a CDF Di-Clad laminate. The combination of epoxy resin and glass cloth was chosen for its outstanding physical and electrical properties. High mechanical strength for direct mounting of the relay was one requirement. Minimum moisture absorption was another. Heat-resistance, arc-resistance, and insulation resistance were other factors which led Phase-Guard to choose CDF Di-Clad® epoxy-glass copper-clad laminates for this tough mechanical-electrical part.

Complete information on the monitoring device is available from Phase-Guard Co., Carnegie, Pa., or Stradley Engineering Co., Pittsburgh. For information on CDF epoxy laminates, write to CDF for Bulletin 11,200.

UNIQUE MATERIALS, MODERN METHODS FOR POWER-EQUIPMENT INSULATION

Arc Chute

Tapes

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shaft (above, left) for an air circuit breaker; Dilecto® laminates (above, right) in completely fabricated or sheet, tube, or rod form; tapes of du Pont TEFLON TFE fluorocarbon resin, silicone-rubber, or Micabond®; and other new and old materials that have proved themselves in severe service.

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Look for CDF's catalog in Sweet's Product Design File, or send for literature pertinent to your interests and immediate needs. Better yet, send us your print or your problem, and we'll return recommendations.

NEW CDF LITERATURE

Information on new grades, special applications, and outstanding properties of CDF insulating materials is made available regularly through CDF Technical Bulletins and Brochures.

The following literature is new. For copies of any bulletins listed, send the coupon below.

Epoxy Laminates—
Bulletin 11,200

Di-Clad Laminates—
Bulletin 11,900

Paper-Base Laminates—
Bulletin 11,110

Celoron Molded Products—
Folder C-59

Glass-Supported "TEFLON"—
Folder GST-58A

Polyester-Glass Laminates—
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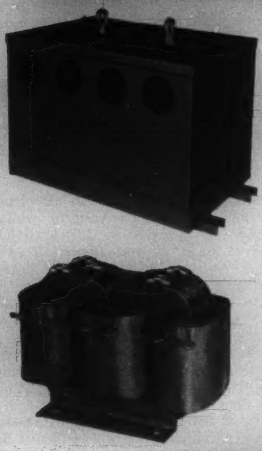

Hevi-Duty Saturable Reactors are used for the manual or automatic control of power to a load. Loads such as electrically heated equipment, motor starting circuits, test boards and many other industrial power uses are ideal applications.

By changing the magnetic characteristics of the reactor core, the impedance can be varied by means of a direct current control winding. This feature provides:

1. **Stepless control in the AC power circuit.**
2. **A wide range of control with smooth and even adjustment over the entire range.**
3. **Small voltage drop in reactor at full saturation, permits 90% of the line voltage to be applied to the load.**

The Hevi-Duty Reactor is a compact unit requiring a minimum of mounting space and is sturdily constructed to give years of dependable service. Each reactor is rigidly tested to meet or exceed NEMA Standards. If you have a Saturable Reactor application, Hevi-Duty engineers will be glad to design or assist you in selecting the proper size for your particular application. For additional information on Hevi-Duty Saturable Reactors, write for Bulletin 500 today.

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Industrial Notes

(Continued from page 36A)

Tracerlab Waltham, Mass. . .

Radioactive clathrates, a unique new source of radiation which combines unusual safety with high-specific activity, is a crystalline form of the chemical hydroquinone combined with gaseous krypton-85. The krypton gas is not chemically bound to the hydro-quinone but is mechanically trapped within cages formed by the molecular structure of the crystal. Clathrates can contain more than 30 times the radioactivity of the same volume of gaseous krypton supplied by Oak Ridge. Clathrates, made available by Tracerlab, 1601 Trapelo Rd., Waltham 54, Mass., may be employed as a radiation source for thickness gauging, production of X rays, static elimination, light sources, and many other applications.

Armour Research Foundation Chicago, Ill. . .

The possibility of achieving greater strength and improvement of electrical properties in commercial plastic materials through electrical field processing has been advanced by scientists of Armour Research Foundation, Illinois Institute of Technology, 33 W. 33rd St., Chicago 16, Ill. Preliminary experimentation has shown that processing a commercial plastic such as polystyrene in an electric field at the same time it is subjected to external heating increases the tensile strength approximately 25%. With plastics being used more widely throughout industry, such improvements in strength and electrical qualities could lead to even more widespread application.

Minneapolis-Honeywell Newton-Highlands, Mass. . .

Air is being used as a lubricant to cushion and control the fast-whirling magnetic tapes on the Honeywell *800* transistorized computer system. Firm "fingers" of air pressures and vacuums have replaced mechanical brakes and clutches traditionally used to guide the movement of data-bearing tape through the reading-writing mechanisms of computers. The system will virtually eliminate tape damage resulting from internally created dust particles. The pneumatic techniques reduce tape wear and slippage by distributing braking and clutching forces over areas 10 times as great as those subjected to mechanical pinching, and add blowing and sucking actions to tape surfaces at the instant of releasing or applying force, thus contributing a cleansing factor. Room dust is virtually eliminated in the system by sealing, filtering, and applying slight air pressures to the tape unit. Minneapolis-Honeywell Regulator Co., 151 Needham Ave., Newton Highlands, Mass.

(Continued on page 50A)

NEW EXPERIMENT IN TELEPHONY

It could speed up "dialing." Bell Laboratories people created it—and now it's being tested.

The telephone you see above embodies an important new concept. It "dials" by means of push buttons—promises more convenient telephoning. Bell System engineers are currently testing it for public reaction. Bell Telephone Laboratories developed it.

The Laboratories' invention of the transistor makes it possible. For the transistor permits a new kind of calling signal generator, mounted within the instrument.

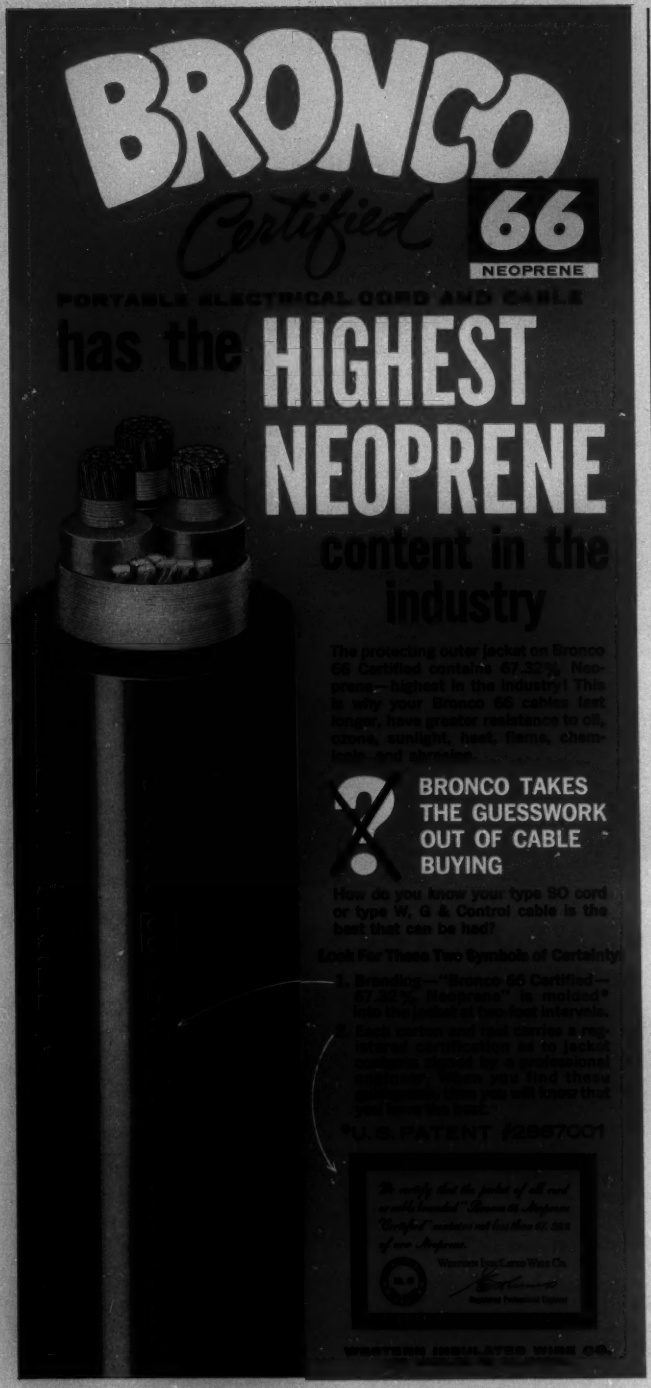
To insure ease of operation, psychologists studied human reactions to various finger pressures and sizes and arrangements of buttons. All factors affecting speed and accuracy were thoroughly evaluated. Electrical and mechanical engineers brought together the human and physical factors, created a practical piece of apparatus. Industrial designers worked out the functional shape.

The new instrument sends a calling signal quite different from that of your present telephone. This poses a problem. Complex automatic switching must be changed to handle the new signals as well as the old ones. Switching engineers must devise ways to make this change in *thousands* of central offices—economically.

Most of the challenges have been met. Final judgment on this new concept depends on the outcome of field tests. Meanwhile, Bell Laboratories continues in its task of originating and developing devices to improve your Bell System telephone service.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



Industrial Notes

(Continued from page 38A)

Burroughs Corp. Pasadena, Calif. . .

A "piggy back" paper-tape unit, the Duplex Tape Input Unit, allows the Burroughs *E101* electronic computer to accept data and instructions from either one of two readers. Coupled with the standard Model *A531* input unit, it increases the *E101*'s versatility by providing the programmer with completely automatic control of two separate tapes. Applications in which the unit, made by Burroughs Corp., ElectroData Division, 460 Sierra Madre Villa, Pasadena, Calif., will prove most useful include payroll, survey closure, statistics, materiel control, highway design, utility billing, and scientific data reduction.

Westinghouse Electric Corp. Pittsburgh, Pa. . .

An astronuclear laboratory where scientists will undertake the development of nuclear energy for outer space has been announced by the Westinghouse Electric Corporation, Box 2278, Pittsburgh 30, Pa. The laboratory will be located in the Pittsburgh, Pa. district and will be part of a new Westinghouse atomic power division that also will include existing activities of the company in the development of commercial applications of atomic energy for electric power generation. This division does not include the Bettis Atomic Power Laboratory of the U.S. Atomic Energy Commission which is operated by Westinghouse.

Hubbard and Co. Chicago, Ill. . .

A new addition doubles the company's Cicero, Ill., plant capacity. Production out of the new facilities is already vastly increased; it is devoted exclusively to pole line hardware. The original sections of Hubbard's Cicero plant have been modernized, also. Employment is being doubled

on a two-shift basis. New equipment has been installed, including a 300-ton blanking and forming press, a 200-ton blanking press, cut threaders, and bar shears. The new plant area includes facilities for blanking, shearing, upsetting, forging, trimming, pointing, cut threading, roll threading, and cold heading, as well as a new tool room, maintenance shop, locker rooms, and a cafeteria. Hubbard and Co., 200 S. Michigan Ave., Chicago 4, Ill.

Learn What's New at the Insulation Conference

You can't afford to miss this opportunity to learn what's new in insulation applications and materials. Here are some of the highlights of the December 8-10 conference.

The technical program is packed with more than 80 high interest, "how-to" papers. Speakers will rely heavily on visual aids and solid, understandable presentations. This one meeting will bring you up to date on most of the recent technological advances in the electrical and electronic insulation fields.

Then too, at the many commercial, industrial, and government exhibits you'll be able to actually see and discuss the latest developments in insulation materials and applications. Some of the other conference features include educational tours, informal "get acquainted" gatherings, and a "news-making" banquet to be attended by top level government and industrial leaders. The cost is very modest—just send in the coupon, now, so that we can send you complete information right away.

P. S. If you manufacture (your company, that is) electrical insulating materials, maybe your products should be exhibited at the show. Check the extra special box in the coupon for all the information.

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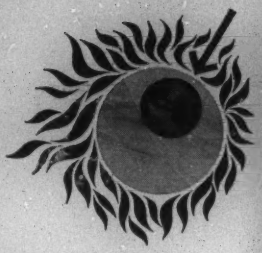

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For full information write to:

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Douglas Aircraft Company, Inc.
Santa Monica, Calif.

Trade Literature...

Test Instrument Catalog . . .

A 24-page catalog listing the complete Bruel & Kjaer line of integrated instruments for automatic measurement of sound, vibration, and strain has been released by **B & K Instruments, Inc., 3044 W. 106th St., Cleveland 11, Ohio.**

Dielectric Test Set . . .

Bulletin 22-5, which describes a new instrument available in two models for making step-voltage-current or resistance tests, voltage withstand, and breakdown tests on the insulation of electric equipment with voltage ratings in the 300-, 600-, and 2,500-volt classes and higher. Complete specifications and price are included in this bulletin which also carefully outlines the many design and operating features of the instrument. **James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.**

Synchro Guides . . .

Two brochures recently published, and available upon request, by the Montrose Division, are "Rapid Reference Guide to Military (BuOrd) Synchros" and "Guide to Military and Commercial Autosyn Synchro Indicators, Autosyn Synchro Transmitters, Aircraft Pressure Switches." **Montrose Division, Bendix Aviation Corp., South Montrose, Pa.**

Computer Publication . . .

This 4-page publication deals with analog computer techniques and applications. Subject of Donner Tech Note No. 1 is "How to Simulate a Non-linear Control System with an Analog Computer." Diagrams of a typical control system and plots showing response of the system at various points with different parameters are included. **Donner Scientific Co., 888 Galindo Rd., Concord, Calif.**

Control Synchro, Control Resolver Testing Report . . .

A 25-page comprehensive report on the latest techniques of control synchro and control resolver testing describes in complete detail the test procedures and application factors associated with electrical zero, electrical error, fundamental null, total null, transformation ratio, and phase shift. A new military specification about to be released will inaugurate new concepts in synchro testing which this report seeks to explain. **Theta Instrument Corp., 48 Pine St., East Paterson, N. J.**

Industrial Truck Driving Instructors' Manual . . .

An instructors' manual to be used as a guide for industrial truck operators' training program is divided into six stages: theory of operation, good driving practices, details of construction in principal types of trucks, practical operation of the truck, demonstration, and written examination for the driver trainee. **Automatic Transportation Co., 149 W. 87th St., Chicago, Ill.**

Preformed Tie Handbook . . .

How to make uniform ties every time without the use of tools is presented in a pocket-sized, illustrated booklet No. 81-301 describing the proper application procedure of the new one-piece preformed communications tie. Charted are various sizes of preformed communications ties as they relate to corresponding insulators and open line wire diameters. **Preformed Line Products Co., 5349 St. Clair Ave., Cleveland 3, Ohio.**

Tomorrow's Lighting Today . . .

Bulletin GEA-6989, 12 pages, illustrates how several cities, both large and small, met the challenge of poorly lighted downtown areas. Recent installations of modern whiteway lighting benefitting citizens, civic officials, and businessmen are pictured in "before" and "after" sequence. Brief application data on these installations is also provided. Mercury, fluorescents, and filament street lighting luminaires are pictured and described. **General Electric Co., Schenectady 5, N. Y.**

Electronic Measuring, Data Handling Systems Brochure . . .

Bulletin G-101, showing the complete range of Gilmore precision electronic measuring and data handling systems has been announced by **Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.**

Compressor Bulletin . . .

This 24-page bulletin A-62 describing the *WN-112* stationary air compressor contains specifications, diagrams, cross section drawings, installation photographs, and other pertinent information. **Joy Manufacturing Co., Oliver Bldg., Pittsburgh 22, Pa.**

Packaged Temperature Chambers . . .

A bulletin describing the model *FT1* packaged temperature chamber includes complete specifications on this small chamber which can be moved about for military specifications temperature testing anywhere within a laboratory or on a production line. **Missimers Inc., 3737 San Fernando Rd., Glendale 4, Calif.**

(Continued on page 66A)

Air brake for a spaceliner

The earth's atmosphere, one of the biggest obstacles to getting into outer space, can be one of our biggest assets coming back. At Douglas we are investigating how we can use its braking effects on rockets returning from deep space trips at far faster than ICBM speeds. Success will allow us to increase payloads by reducing the weight of soft landing systems. This technique also will aid us in pinpointing landing areas. Current reports show real progress. Douglas is engaged in intensive research on every aspect of space planning, from environmental conditions on other planets to the destroyer-sized space ships necessary to get there. We invite qualified engineers and scientists to join us. Some of our immediate needs are listed in the column on the facing page. Please read it.

Arthur Shef, Chief, Advanced Design Section, Missiles and Space Systems, irons out a problem with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

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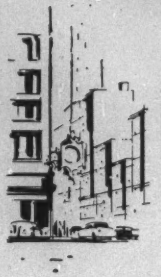

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PORTABLE COMMUNICATIONS
• Design of VHF & UHF FM Communications in portable or subminiature development.

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Trade Literature

(Continued from page 64A)

Platinum-Group Metal Products Booklet . . .

An 8-page general brochure, "Platinum-Group Metals," briefly describes platinum-metal products including solid and clad platinum metals and alloys in sheet, strip, wire, foil, and seamless tubing; parts, shapes, and specialties; dental foil, electrical contacts, electrodes, gauze, catalysts, salts and derivatives, expanded anodes, laboratory ware, rhodium plating solutions, transistor materials, and thermocouple wire. Services offered are smelting, residue preparation, sampling, assays, refining, and chemical analysis. **Metals & Controls Division, Texas Instruments Inc., 34 Forest St., Attleboro, Mass.**

Basic Circuits Booklet . . .

This 32-page booklet, designed to serve as a guide to determine the availability of a circuit and its components, contains line drawings that show relay transfer trees, relay coil symbols, and relay coil terminal connections. Other sketches illustrate slow-operating and slow-releasing circuits, relay locking circuits, pulse generators, pulse stretching, a-c rectifier circuits, rotary switch circuits, etc. In addition to the pamphlet, the company offers a unique relay and switch symbol template to simplify and standardize circuit drawings. Write attention, Director of Control Equipment Sales, **Automatic Electric, Northlake, Ill.**

Ground Handling Equipment Sheet . . .

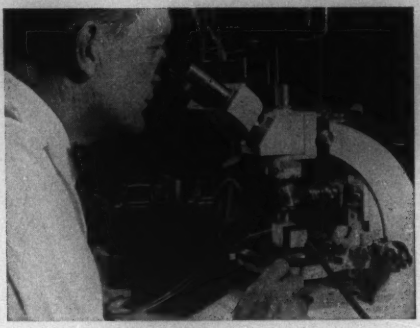
Data sheet No. 591 on ground handling equipment provides information on missile and engine containers, fuel tanks and engine assembly containers, etc., as well as containers for smaller components. **Royal Jet, Inc., at 1035 Westminster Ave., Alhambra, Calif.**

Welding Power Sources Reprint . . .

A reprint of an article on arc welding power sources entitled "Which Welding-Power Source Should You Use," (Form ADR 121), offers a comprehensive guide to the proper selection of arc welders for use with the stick electrode, gas shielded tungsten-arc, or gas-shielded metal-arc welding processes. Illustrated with 14 schematic drawings, the article details eight specific steps to be taken into account when choosing one of the four basic types of power sources: location of the operation, job and process requirements, type of current, machine characteristics, auxiliary devices in the power source, welding power, welding duty cycle, and shop power supply voltage. **Air Reduction Sales Co., a division of Air Reduction Co., Inc., 150 E. 42nd St., New York 17, N. Y.**

(Continued on page 72A)

Everywhere Hughes systems and missiles *are employed, Hughes Field Engineers insure maximum utilization and field performance.*



Developing new semiconductor materials, *physicists at the Semiconductor Division of Hughes Products utilize highly advanced techniques.*

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Operating with accuracy at speeds far beyond man's ability to reason and act, the control systems produced by Hughes-El Segundo are blazing new trails in the state of the art.

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This work demands engineers of special ability, who are capable of translating theory into hardware of fantastic accuracy and dependability. A large share of engineering time at Hughes El Segundo is spent in the continuing development of these systems... and in the development of equipment and methods to support the program.

The systems philosophy is characteristic of all Hughes activities...covering the spectrum of electronic progress: space vehicles, plastics, nuclear electronics, infrared devices, advanced data processing and display systems, microwaves, global communications, ballistics missiles and many others. These activities provide stimulating outlets for creative engineering talents.

Hughes Products, the commercial activity of Hughes, has assignments for imaginative engineers in several areas of research in semiconductor materials and electron tubes.

The great variety of advanced projects...the stability stemming from a position of leadership ...and Hughes engineering-orientation creates an ideal environment for the engineer or scientist interested in advancing his professional status.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

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Plasma Physics	Circuit Design & Evaluation
Field Engineering	Systems Design & Analysis
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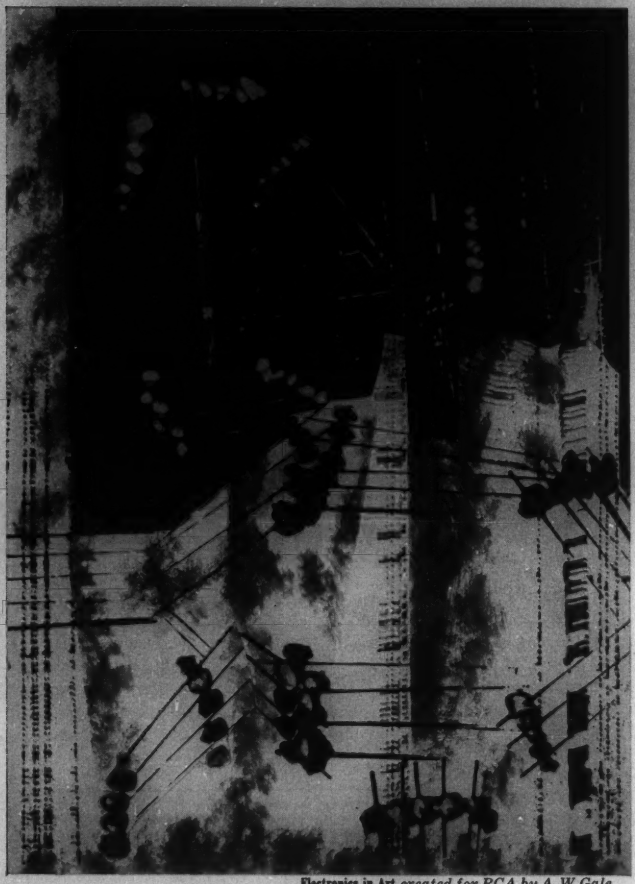

Electronics in Art *created for RCA by A. W. Gale*

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RCA **RADIO CORPORATION OF AMERICA**

Electron Tube Division • Harrison, New Jersey

Personnel Service, Inc.

(Continued from page 62A)

but informal product orientation. Adequate salary while training; when assigned a territory will be on a salary—commission plus expenses contract. Territories: Northeast Long Island and New York City; Midwest. Headquarters, Pennsylvania. W7784.

ASSISTANT SALES MANAGER, Electronic Sub-Systems, graduate engineer, with substantial successful selling and management experience in the sale of electronic systems and sub-systems to major aircraft, avionic and electronic organizations. Must be capable of promoting joint team efforts in major systems programs. Salary open. Location, New York suburban area. W7792.

TECHNICAL MANAGER, graduate mechanical or electrical, with a minimum of ten years' in instrument engineering including creative instrument design and systems design preferably with some hydraulics and fluid flow background to take charge of research, mechanical engineering and electrical engineering, including design of electrical, mechanical and pneumatic instruments and systems pertaining thereto primarily in the control of fluid flow. Location, East. W7802.

EXECUTIVE SALES ENGINEER, graduate electrical, to be responsible for handling all levels of negotiation with a limited number of customers of major magnitude, covering devices for electronic computer systems. Salary, attractive; excellent fringe benefits. Location, East Coast. W7807.

ENGINEERS. (a) Electrical Engineer with five years' experience in heavy industry for design and engineering in a paper mill. Instrumentation engineering desirable. Position will lead into electrical superintendent with responsibility for generation, distribution and utilization of same. Salary, about $8000 a year to start. (b) Process and Maintenance Engineer with five years' experience in the paper industry, to do general process and maintenance engineering in an integrated newsprint mill. Salary, about $7500 a year to start. Location, New England. W7808.

ELECTRICAL ENGINEER, graduate, with design, development, application or test experience, to be responsible for sub-contractor relations, order placement, follow-up of magnetic amplifiers, electro-mechanical relays and similar control panel components. One to ten years' experience desired. Salary, to $9000 a year. Company pays placement fee, interview and relocation expenses. Location, western Pennsylvania. W7818.

ENGINEERS. (a) Assistant Chief Engineer, graduate electrical, with at least five years' experience in project engineering responsibility dealing with audio amplifiers and FM tuners. Complete acquaintance with high fidelity components and design philosophies. Salary, $12,000 a year to start. (b) Electro-Mechanical Design Engineer, with a minimum of five years' design experience. Must be familiar with small motors, solenoids, etc.; their specification and application. Precision mechanisms experience for production design; tape and disc recording equipment design desirable. Salary, $10,000 a year to start. Location, northern New Jersey. W7824.

METHODS ENGINEER, graduate electrical, with experience in the manufacture of electronic components, assemblies and the use of electronic testing equipment, to plan and direct "in process" inspection of each step in the manufacture of magnetic recording tape, including electrical tests of the finished product. Salary open. Location, South. W7835.

ELECTRICAL ENGINEER, graduate, with at least five years' supervisory installation and operating experience of electrical equipment and controls in oil refining or chemical industries. Explosive hazards and corrosion essential. Salary, $15,000 a year plus extras. Location, Korea. F7847.

(Continued on page 74A)

CURRENT ASSIGNMENTS . . .

MAGNETICS ENGINEER to design and analyze magnetic core circuitry for use in advanced digital computers. Must understand application of these circuits to logical connectives and systems, and be familiar with basic fundamentals of nonlinear magnetics. Qualifications: B.S., M.S., or Ph.D. in E.E. or Engineering Physics plus 2 to 5 years' experience with magnetic circuits and a strong interest in logical circuit application of magnetics.

CIRCUIT ENGINEER to develop advanced circuit designs based on transistor-diode logic for digital systems; to review new circuits for application in digital control systems and define basic techniques for improving performance characteristics; to participate in advanced analytical studies associated with the application of transistor circuitry to pulse and digital systems. Qualifications: B.S., M.S., or Ph.D. in Electrical Engineering. Minimum of two years' experience with pulse circuitry, transistor circuit design or digital techniques. A knowledge of magnetic devices or solid state physics is highly desirable.

CHEMIST AND PHYSICAL CHEMIST to initiate fundamental studies of the phenomena of surface boundary layers relating to absorption friction, wear, and surface energy states. Qualifications: B.S., M.S., or Ph.D. degree in Chemistry, Chemical Engineering, or Physical Chemistry and suitable experience.

SOLID STATE ENGINEER to carry out applied research studies on precision linear circuitry employing solid state devices. Qualifications: B.S., M.S., or Ph.D. degree plus experience in feedback amplifier and servo design.

METALLURGICAL OR PHYSICAL ENGINEER to handle research and advanced development relating to electrical connections, vacuum melted metals, and thin film techniques. Qualifications: B.S. in Physics or Metallurgy plus extensive knowledge of materials and means of joining metals. Thoroughly experienced with metallograph, photomicrography, and experimental techniques.

PHYSICIST to supervise efforts in integrated circuit development and fabrication using variety of thin film components. Qualifications: Advanced degree in Physics and well-qualified experimental experience.

SEMICONDUCTOR PHYSICIST OR ENGINEER to direct projects dealing with design and process development of advanced types of high-frequency and multi-element semiconductor devices. Qualifications: M.S. or Ph.D. in Physics or E.E. with 2 years' experience in semiconductor field.

For details, write, outlining background and interests, to:

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INTERNATIONAL BUSINESS MACHINES CORPORATION

Trade Literature

(Continued from page 66A)

Leak Detector Bulletin . . .

Type *24-210A* leak detector, suitable for testing of both vacuum and pressure systems, is described in a 4-page brochure showing applications, specifications, and operation of this portable, mass-spectrometer-type leak detector. Bulletin 1830 is available from **Analytical and Control Instrument Division, Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.**

Automatic Soldering Guide . . .

An 8-page booklet, "A Guide to Preform Soldering," includes data on the range of preform shapes, the alloys from which they are made, and their use in automated production processes. The guide also describes heating methods, flux selection, metals characteristics, and alloy selection. It contains a detailed temperature conversion chart as well as solder reference data. **Alloys Unlimited, Inc., 21-01 43rd Ave., Long Island City 1, N. Y.**

Field Service Capabilities Brochure . . .

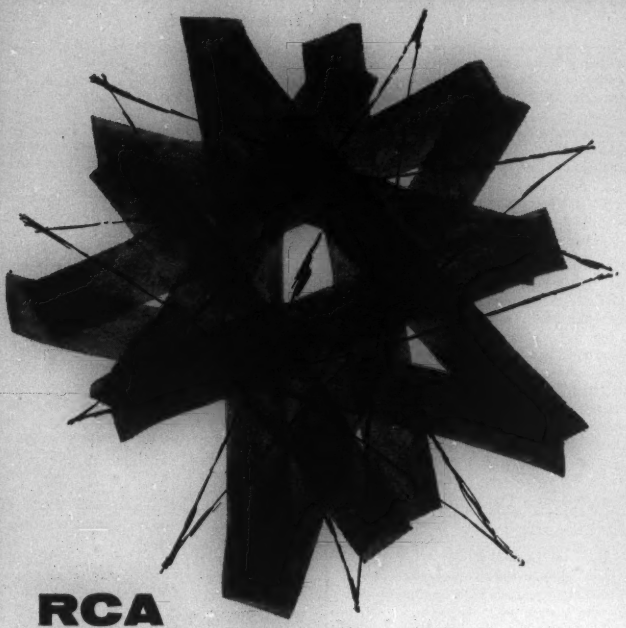
A 8-page, illustrated brochure outlines the field services Hoffman offers on a world-wide basis in the areas of field engineering, overhaul and repair, test equipment, standards, training, and medical electronics. **Field Services, Laboratories Division, Hoffman Electronics Corp., 3740 S. Grand Ave., Los Angeles, Calif.**

Fire Fighting Brochure . . .

A 16-page brochure, P-49, describes and illustrates all types of portable fire extinguishers, wheeled units, built-in carbon dioxide extinguishing systems, and several types of fire detection devices. Entirely new designs of pressurized extinguishers are included in the booklet. Also contained is a chart which shows which extinguishers are approved for use on each class of fire. **Walter Kidde & Co., Inc., Main St., Belleville 9, N. J.**

Computer Booklets . . .

Two booklets offered by Computer Control Co., Inc., are "Symbolic Logic, Boolean Algebra and the Design of Digital Systems" and "Computing Services." The first is a 36-page booklet which presents in a clear and understandable form the fundamentals of Symbolic Logic as applied to the logical design of digital systems. The second brochure gives an account of mathematical services for scientific, industrial, and business applications provided by this company. Types of mathematical and organizational services are listed. **Computer Control Co., Inc., Mathematical Services Dept., 2251 Barry Ave., Los Angeles 64, Calif.**



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Personnel Service, Inc.

(Continued from page 70A)

APPLICATION ENGINEER, graduate electrical, preferably with experience in rotating machinery or control systems experience; or controls design. Will consider recent graduate but man with experience preferred. Will work with customers and field sales engineers on application of equipment to customers' requirements. Salary, $6000-$10,000 a year depending upon experience. Location, Connecticut. W7851.

ENGINEERS, graduate chemical, electrical, mechanical, 25-35, with strong background in industrial instrumentation and process control, experience as engineers in the chemical, petroleum, gas or power industries. Sales minded, able to work with field sales personnel, customers and home plant engineering departments. Travel about 25% of time. Salary based on education, experience and abilities. Headquarters, Massachusetts. W7857.

CONTRACTS MANAGER to handle all incoming mail regarding requests for quotations, handle customer inquiries, for an electronics manufacturer; must be able to establish good customer relations. Will work with production department regarding estimates, follow-ups, institution of contract orders, etc. Some sales experience desirable. Excellent opportunity. Salary, to $10,000 a year. Location, New England. W7858.

TEACHING PERSONNEL in electrical engineering, B.S. or M.S. degree in electrical engineering, to teach subjects such as electronics, instrumentation, servo mechanisms, electrical control systems, electric machines, electric circuits. Must have had considerable experience in industry or in teaching. Rank and salary dependent upon background. Location, Michigan. W7886.

ASSOCIATE EDITOR, not over 35, graduate mechanical or electrical, with at least two to four years' of power engineering operating experience in utilities or industry or both. P.E. license desirable. Also some knowledge of diesel, hydro, refrigeration, air conditioning and compressed air practices desirable. Should be able to write but previous editorial experience not necessary. Some travel. Salary, $6000-$9500 a year depending upon experience and background. Location, Midwest. W7898.

INSTRUCTOR OR ASSISTANT PROFESSOR, graduate E.E., about 30. Duties: At instructor or assistant professor level to teach electrical and electronic subjects. Good opportunity as engineering staff is expanding and advancement rapid for person with proven ability. Salary, $5000 plus for nine months. Location, South. C7641.

DEVELOPMENT ENGINEER INSTRUMENTS AND METERS, graduate E.E. or M.E., with five or more years' experience in large steel mill or process industry, on design of electrical instrument control systems involving selection of components involving a wide range of instruments. Will also consider applicant with broad experience in operation and maintenance of electrical control instruments and mechanisms, or with manufacturer or consultant where similar experience has been obtained for a manufacturer. Salary, $7000 a year plus good fringe benefits. Location, Indiana. C7645.

ASSISTANT PROFESSOR—ELECTRICAL ENGINEERING: Min MS, (PhD pref), to teach undergraduate courses. Former teaching and professional experience desirable, although not necessary. U.S. citizen desired. Salary commensurate with rank and experience. Pacific Island. S(P)-4644-R

DESIGN—ELECTRICAL CONTROL SYSTEMS: EE, with advanced control engineering, to 45. Recent and solid experience at high level in all phases if complex industrial motor control relating to use, application and operation of special and varied components such as magnetic

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